Microlog Microfiche Collection
Resolution Chart

Copyright

Copyright for the ***contents*** of this microfiche is held by the publisher of the original document. Please contact the original publisher for guidance in all copyright matters. Copyright in this ***microfiche edition*** is held by Micromedia Limited.

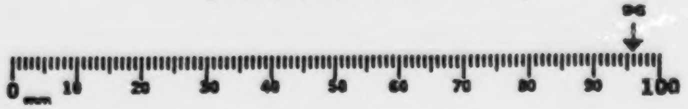
Quality of the Microfiche Reproduction

Micromedia Limited maintains the highest standards for micrographic reproduction. Attempts are made to obtain the best quality print version to microfilm. However, there are some printing styles, colours and graphic layout styles (including maps, graphs and tables) which do not reproduce well. Because of the value of the original document, Micromedia has filmed it recognizing that it may not be as easy to read as the original document.

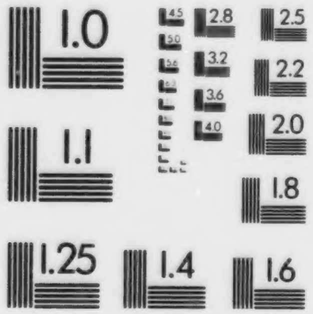
Some pages have been filmed twice to improve the clarity of the reproduction. Consult both reproductions to ensure that all of the original text is read.

Microcopy Resolution Test Chart

National Bureau of Standards
Standard Reference Material 1010a
(ANSI and ISO Test Chart No. 2)



PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT



MS109

24x

micro|media
a division of IHS Canada

20 Victoria Street, Toronto, ON M5C 2N8
Tel.: (416) 362-5211
Toll free: 1-800-387-2689
Fax: (416) 362-6161

Collection MICROLOG sur Micromédia
Tableau de résolution

Droits d'auteurs

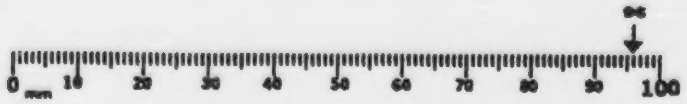
Les droits d'auteurs du conenu de cette microfiche sont détenus par l'éditeur du document original. Veuillez communiquer avec celui-ci pour obtenir des renseignements sur tout ce qui touche les droits d'auteurs. Les droits d'auteurs de cette édition sur microfiche sont détenus par Micromédia Limitée.

Qualité de reproduction sur microfiche

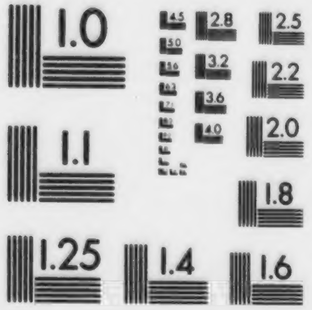
Micromédia Limitée maintient les normes de reproduction micrographique les plus élevées. Elle fait tout son possible pour obtenir la version sur papier à reproduire sur microfiche de la meilleure qualité possible. Cependant, certains styles d'imprimerie, de couleurs et de style de mise en page graphique (incluant des cartes, des grahiques et des tableaux) se reproduisent mal. En raison de la valeur du document original, Micromédia l'a reproduit tout en reconnaissant qu'il ne sera peut-être pas aussi lisable que le document original.

Tableau de résolution micrographique

National Bureau of Standards
Standard Reference Material 1010a
(ANSI and ISO Test Chart No. 2)



PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT



MS109

24x

micro|media
a division of IHS Canada

20 Victoria Street, Toronto, ON M5C 2N8
Tel.: (416) 362-5211
Toll free: 1-800-387-2689
Fax: (416) 362-6161

MINERALS AND ENERGY BRANCH

REPORT OF ACTIVITIES

1998

REPORT ME 1999-1
EDS. D. R. MACDONALD AND K. A. MILLS

NOVA SCOTIA
Natural Resources

Honourable Kennie MacAskill
Minister

D.J. Graham
Deputy Minister

Halifax, Nova Scotia
1999

Cover photo

Photographs of carbonate rock associated with Zn-Pb-Cu mineralization at the 680 Ma Stirling massive sulphide deposit, Richmond County, Cape Breton Island. This rock fits the description of calcareous sinter or travertine deposits formed in hot spring environments (80-100°C), such as Yellowstone Park, U.S.A. In the lower right is a hand specimen of colloform-textured carbonate rock showing intricate compositional layering defined by alternating bands of magnesite ($MgCO_3$) and dolomite ($Ca, Mg (CO_3)$). The effects of weathering cause differential oxidation of Fe in the carbonate layers which enhances the texture. Sample is ca. 15 cm long. Centre photo is a close-up of the specimen illustrating the intricate nature of the texture and natural beauty of the features. Note that the textures indicate that the carbonate grew inwards and upwards into an open space or water-saturated environment, since growth must have proceeded unimpeded. Upper right is a photomicrograph of a thin section in crossed nicols, illustrating the colloform- and radial-texture of the carbonate with late infill of another carbonate phase and minor talc. Photomicrograph is ca. 2.5 mm wide.

Editors: D. R. MacDonald
K. A. Mills

Word Processing: B. L. MacDonald

Cartography: J. Campbell
W. Burt
P. Belliveau
C. Phillips
P. Fraser
J. Webster
E. McNamara

Photography: C. Murphy

Publications of the Nova Scotia Department of Natural Resources are available through the departmental libray at:

1701 Hollis Street, 3rd Floor
Halifax, Nova Scotia
B3J 2T9
902-424-8633

Table of Contents

Page

Minerals and Energy Branch Activities

Sedimentology and stratigraphy of the Lower Cove redbeds in the Cumberland Basin - *J. H. Calder and B. Hebert* 1

The Prospector Assistance Program: nourishing the grass roots of the mineral industry - *H. V. Donohoe, Jr.* 5

Minerals Education Program: a program with continuing purpose - *H. V. Donohoe, Jr.* 9

Industrial Mineral activities, 1998 - *P. W. Finck* 11

Digital Information Services - *B. Fisher and J. Poole* 13

Musquodoboit Batholith Project: geological mapping of the Musquodoboit Harbour area (NTS 11D/14) - *L. J. Ham* 15

Mineral Resource Land-use Information and Policy - *D. B. Hopper and F. J. Boner* 21

Geochemical profile of a carbonate-quartz alteration zone in footwall rocks of the Stirling VMS base metal deposit, Richmond County, Cape Breton Island - *D. J. Kontak* 25

Geoscience Editing and Publishing - *D. R. MacDonald, B. L. MacDonald, K. A. Mills, J. S. Saunders and A. Miller* 39

Mining Matters for Nova Scotia '98: forging new partnerships - *M. A. MacDonald* 43

Mineral exploration activity in Nova Scotia - *P. D. McCulloch* 47

Drill Core Library programs, 1998 - *J. M. McMullin, W. Palmer, D. Weir and J. Horton* 55

Parallels between paleoplacer development in northern Nova Scotia and southern New Brunswick - *R. F. Mills* 61

Progress report on geological mapping in the Parrsboro area (NTS 21H/08), Cumberland County, Nova Scotia - *R. D. Naylor, K. Adams, J. H. Calder, T. A. Costain and B. A McCarthy* 69

Fluvio-estuarine sedimentation in the Late Carboniferous Malagash Formation of Nova Scotia, Canada -*R. D.Naylor, A. W. Archer, F. W. Chandler and P. W. Fralick* 71

Mineral Inventory activities for 1998 - *G. A. O'Reilly and G. J. DeMont* 91

Aggregate Program - *G. Prime* 95

1998 progress report for the Eastern Shore Project - *P. K. Smith and L. J. Ham* 99

Mapping and 3-dimensional stratigraphic modelling of unconsolidated Mesozoic and Cenozoic deposits in Nova Scotia: plans for the new millennium - *R. R. Stea* 101

Geology of the Guysborough - Mulgrave - L'Ardoise area: a progress report - *C. E. White and S. M. Barr* 105

Preliminary bedrock geology of the Digby map sheet (21A/12), southwestern Nova Scotia - *C. E. White, R. J. Horne, C. Muir and J. Hunter* 119

External Abstracts and Conference Presentations

Fluid composition and thermal regime during Zn-Pb mineralization in the Lower Windsor Group, Nova Scotia, Canada - *G. Chi, D. J. Kontak and A. E. Williams-Jones* 135

Modeling fluid-rock interaction during greisenization at the East Kemptville tin deposit: implications for mineralization - *W. E. Halter, A. E. Williams-Jones and D. J. Kontak* 136

Origin and evolution of the greisenizing fluid at the East Kemptville tin deposit, Nova Scotia, Canada - *W. E. Halter, A. E. Williams-Jones and D. J. Kontak* 137

A study of fluid inclusions in sulfide and non-sulfide mineral phases from a carbonate-hosted Zn-Pb deposit, Gays River, Nova Scotia - *D. J. Kontak* 138

Geology of the Stirling Zn-Pb-Cu-Ag-Au VMS deposit, southeast Cape Breton, Nova Scotia: reinterpretation of the quartz-talc-carbonate (QTC) rock with implications for mineral exploration - *D. J. Kontak* 139

Results of mineral deposit studies at the granite-hosted Dunbrack (Zn-Pb-Cu-Ag) and Kinsac (Ba-F) localities, central Meguma Terrane, Nova Scotia: possible implications for Carboniferous Zn-Pb-Cu-Ag-Ba-F metallogeny in the Meguma Zone - *D. J. Kontak, R. J. Horne and K. Ansdell* 140

^{40}Ar/^{39}Ar dating of ribbon-textured veins and wall-rock material from Meguma lode gold deposits, Nova Scotia: implications for timing and duration of vein formation in slate-belt hosted vein gold deposits - *D. J. Kontak, R. J. Horne, S. Harnish, D. Archibald and J. K. W. Lee* 142

Petrology of Late Cretaceous (ca. 90 Ma) lamprophyric dykes from north Greenland - *D. J. Kontak, S. M. Jensen, J. Dostal, D. A. Archibald and K. Kyser* 143

Aqueous and liquid petroleum inclusions in barite from the Walton Deposit, Nova Scotia, Canada: a Carboniferous, carbonate-hosted Ba-Pb-Zn-Cu-Ag deposit - *D. J. Kontak and D. F. Sangster* 144

Geology of the B baseline zone, Walton Cu-Pb-Zn-Ag- Ba deposit, Nova Scotia, Canada - *D. F. Sangster, M. D. Burtt and D. J. Kontak* 145

A genetic model for mineralization of Lower Windsor (Viséan) carbonate rocks of Nova Scotia, Canada - *D. F. Sangster, M. M. Savard and D. J. Kontak* 146

Sub-basin-specific Pb and Sr sources in Zn-Pb deposits of the Lower Windsor Group, Nova Scotia, Canada - *D. F. Sangster, M. M. Savard and D. J. Kontak* 148

δ^{13}C-δ^{18}O-^{87}Sr/^{86}Sr covariations in ore-stage calcites at and around the Gays River Zn-Pb deposit (Nova Scotia, Canada) - evidence for fluid mixing - *M. M. Savard and D. J. Kontak* 149

Glacial retreat and relative sea-level changes in Maritime Canada - *R. R. Stea and G. B. Fader* 150

Deglaciation of Nova Scotia: stratigraphy and chronology of lake sediment cores and buried organic sections - *R. R. Stea and R. J. Mott* 151

Using whole rock geochemistry to locate the source of igneous erratics from drumlins on the Atlantic Coast of Nova Scotia - *R. R. Stea and G. Pe-Piper* 152

Wisconsinan glacial and sea-level history of Maritime Canada and the adjacent continental shelf: a correlation of land and sea events - *R. R. Stea, D. J. W. Piper, G. B. J. Fader and R. Boyd* 153

Appendix 1 - Mining Industry Activity in Nova Scotia, 1997 155

Appendix 2 - Minerals and Energy Branch Geoscience Maps and Publications for Sale 169

Appendix 3 - Minerals and Energy Branch Digital Geoscience Data for Sale 209

Sedimentology and stratigraphy of the Lower Cove redbeds in the Cumberland Basin

J. H. Calder and B. Hebert

Introduction

During 1997, the authors described a problematic interval of redbeds lying stratigraphically above the South Reef of the Boss Point Formation at Lower Cove and below the base of coal-bearing rocks of the Joggins Formation. This was undertaken as a contribution toward an updated sedimentological log of the Joggins section, in collaboration with Martin Gibling, Dalhousie University, and Sarah Davies, University of Edinburgh. The interval constitutes 468 m of strata that coincide with Division V of Logan (1845). The section constitutes the link between the Boss Point and Joggins formations, but its sedimentology reveals lithologic attributes distinct from either of the two.

The following report provides a first summary for a significant portion of the Joggins section. The work to date constitutes a sedimentological framework to which detailed information can be added later. Measurements of paleoflow indicators and a more rigorous examination of the paleontological record, not undertaken because of time constraints, are examples of recommended supplemental data.

The Section

The section occurs along a stretch of Chignecto Bay north of and stratigraphically older than the 'classic' Joggins coal-bearing section (Fig. 1). Along this portion of the greater Joggins section, the cliff face drops in elevation to a few metres in the vicinity of Little River, north to Lower Cove.

Outcrop is encountered mainly within the intertidal zone, although bedrock forms small headlands and bluffs locally, particularly in the north at Lower Cove. Sandstone bodies are best exposed elsewhere as intertidal 'reefs', with mudrocks exposed ephemerally on the lower shore face and best exposed where the cobble shingle has been cleared by weir fishers.

Logan (1845) estimated the thickness of Division V to be 635 m, of which 226 m or 36% of the section was recorded as 'measures concealed'. Rigorous examination of the intertidal zone resulted in a section log with only 89 m (19%) concealed, the greater part of which occurs in the vicinity of the outwash bars at the mouth of Little River. The total thickness of our measured section (468 m) is significantly less than the 635 m measured by Logan, a fact that doubtless can be attributed to the difficulty in estimating the thickness of concealed and low-lying intervals. The section was logged graphically in the field at a scale of 1:100 and currently is being digitally redrafted using AutoCAD®. A representative portion of the section is depicted in Figure 2.

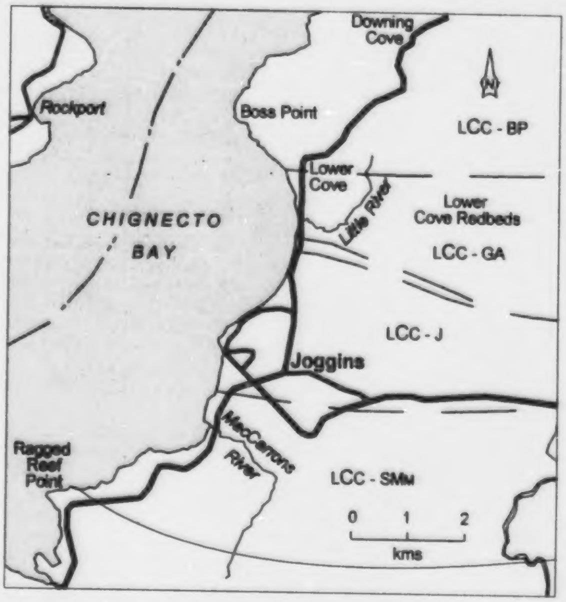


Figure 1. Geological map of the Joggins area.

Sedimentological Overview

The section is dominated by mudrocks (siltstone and claystone), which constitute over 65% of the exposed measured section. The maximum aggregate thickness of sandstone bodies within the redbeds is 134 m; however, many of the bodies are laterally discontinuous across the

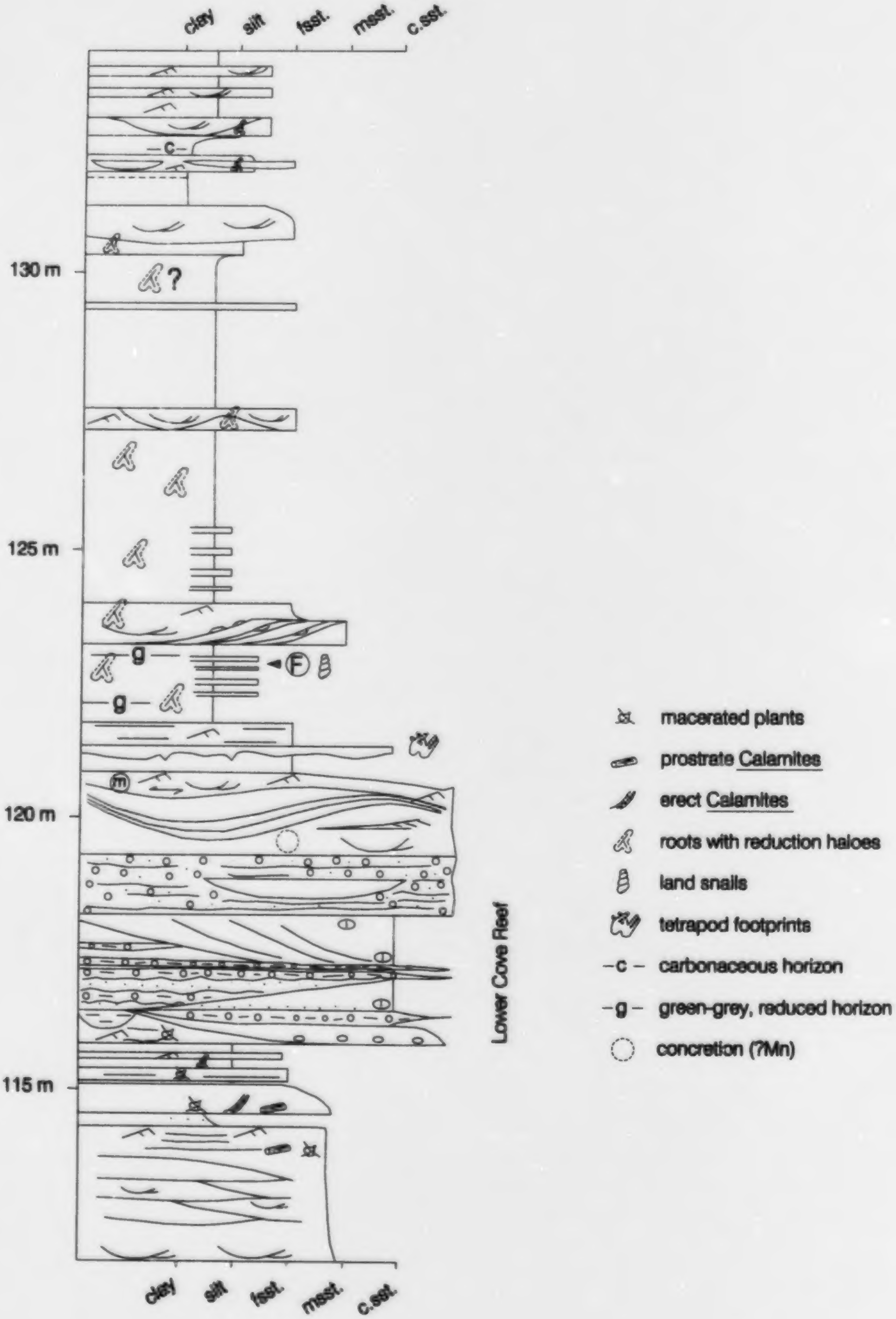

clay
silt
fsst.
msst.
c.sst.
-c-
130 m
?
125 m
g
F
g
m
120 m
Lower Cove Reef
115 m
macerated plants
prostrate Calamites
erect Calamites
roots with reduction haloes
land snails
tetrapod footprints
-c - carbonaceous horizon
-g - green-grey, reduced horizon
concretion (?Mn)

Figure 2. Representative section (from 112-134 m) of the Lower Cove redbeds.

intertidal zone, hence their actual volumetric contribution to this portion of the basin fill is less. Mudrocks are exclusively red with ubiquitous pale grey to greenish mottled root haloes, and calcrete. Coal beds *sensu stricto* are absent within the exposed section, although thin, reduced organic-rich layers persist for tens of metres laterally.

Sandstone bodies seldom exceed 5 m in thickness, with a maximum recorded thickness of 8 m. Bodies were observed to sharply incise mudrocks locally by up to 3.5 m. The lower beds of the sandstone bodies generally comprise trough and planar cross-stratified sets. Sandstone bodies commonly are nested laterally and occur as isolated lenses with abandoned hollow fills within mudrocks. A sinusoidal, concordant sand wave form with an amplitude of 1.5 m and wavelength of 13.4 m occurs within an unusual, 5 m thick sandstone body at 120 m (Fig. 3). The basal 3.5 m of the sandstone body comprise one metre thick cross sets with a matrix composed of mud aggregate granules with red lutite intraclasts.

The strata evoke a significantly water-stressed environment with sudden episodic flood events, and sediment-starved channels with periodic cannibalism of indurated floodplain sediments.

Preliminary Paleontology

The strata generally have a depauparate floral record, which includes the sphenopsid *Calamites cisti* as its most common element, and more rarely *C. suckowi*. The flora include medullosan stems and seeds (charred *Trigonocarpus*) and other indeterminant stems. Lycopsid compressions are uncommon and tend to be concentrated at specific horizons, and include stems of '*Lepidodendron*' and *Sigillaria cf. rugosa* and lycopsid foliage (*Cyperites*).

Faunal occurrences include a green-grey horizon (at 123 m, Fig. 3) rich in the land snail *Dendropupa vetusta*, which is the lowest known occurrence of the fauna at Joggins, hence the oldest occurrence of pulmonate gastropods known. The ichnological record includes vertebrate tracks (cf. *Palaeosauropus* sp. to which the interim working name 'Rex' has been applied by the author in other investigations; at 122 m, Fig. 3) and a *Diplichnites* trail (at 360 m), ascribed to the gigantic invertebrate *Arthropleura*.

Stratigraphic Implications

Logan recognized the distinct lithology of the redbeds at Lower Cove by assigning them to his Division V. Since that time, the strata have been assigned either to the coal-bearing Joggins Formation or to the conglomeratic Polly Brook Formation, albeit with their distinctiveness noted. Shaw (1951) assigned the Lower Cove redbeds to his map unit 10a ("red shale and sandstone"), a distinct subunit of the coal-bearing strata of the Joggins section. Copeland (1959) assigned the strata to his Lower Coarse Facies, and in so doing correlated the Lower Cove redbeds with basin margin conglomerates of the southern and eastern Athol subbasin, now assigned to the Polly Brook Formation (Ryan *et al.*, 1991). The redbed interval subsequently was re-assigned on the map of Ryan *et al.* (1990) to the coal-bearing strata of the Joggins Formation, but their distinctiveness was noted by demarcating the interval with a map boundary and denoting the unit "abundant redbeds". This informal map unit extends inland from the coast at Lower Cove to north of Springhill, some 28 km to the east, where it pinches out between the underlying Polly Brook Formation and overlying coal measures of the Joggins Formation. The Lower Cove redbeds were referred by Ryan and Boehner (1994, their Fig. 2-13) to an informal unit of the Joggins Formation, their Little River Bridge member, although this designation was never formally proposed.

The absence of coal beds and pervasive reddening argue against inclusion of the Lower Cove redbeds in the Joggins Formation as defined by Ryan *et al.*, 1992. The sandstone bodies of the Lower Cove redbed unit stand in marked contrast to the very thick, well sorted, green-grey sandstones of the underlying Boss Point Formation, which were an historic source for grindstones at Lower Cove in the nineteenth century. The Lower Cove redbeds appear to be at least in part stratigraphically equivalent to the Polly Brook Formation conglomerates, which represent alluvial fan deposits on the north piedmont of the Cobequid Highlands massif. Although some evidence of relatively fine extrabasinal lithic clasts occurs within the sequence, the Lower Cove redbeds are distinctly fine-grained in comparison with the Polly Brook Formation.

The Lower Cove redbeds share a similar stratigraphic position and lithologic attributes with redbeds exposed to the west on Cape Maringouin, New Brunswick, and recently named the Grand Anse Formation (Johnson,

1996) of the Cumberland Group. Their assignment to that formation appears to be justified.

References

Copeland, M. J. 1959: Coalfields, west half Cumberland County, Nova Scotia; Geological Survey of Canada, Memoir 298, 89 p.

Johnson, S. C. 1996: Lithostratigraphic revision of Westphalian strata of the Salisbury Formation and the implications for a group boundary in southeastern New Brunswick; *in* Current Research 1995, ed. B. M. W. Carrol; New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Report 96-1, p. 45-60.

Logan, W. E. 1845: A section of the Nova Scotia coal measures as developed at the Joggins, on the Bay of Fundy, in descending order, from the neighbourhood of the West Ragged Reef to Minudie, reduced to vertical thickness; Geological Survey of Canada, Report of Progress 1843, Appendix.

Ryan, R. J. and Boehner, R. C. 1994: Geology of the Cumberland Basin, Cumberland, Colchester and Pictou Counties, Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branches Memoir 10, 222 p.

Ryan, R. J., Boehner, R. C., Deal, A. and Calder, J. H. 1990: Cumberland Basin geology, Amherst, Springhill and Parrsboro, Cumberland County; Nova Scotia Department of Mines and Energy, Map 90-12, scale 1:50 000.

Ryan, R. J., Boehner, R. C. and Calder, J. H. 1991: Lithostratigraphic revision of the Upper Carboniferous to Lower Permian strata in the Cumberland Basin, Nova Scotia, and the regional implications for the Maritimes basin in Atlantic Canada; Bulletin of the Canadian Society of Petroleum Geologists, v. 39, p. 289-314.

Shaw, W. S. 1951: Preliminary map, Springhill, Cumberland, Colchester Counties, Nova Scotia; Geological Survey of Canada, Paper 51-11.

The Prospector Assistance Program: nourishing the grass roots of the mineral industry

H. V. Donohoe, Jr.

The Prospector Assistance Program helps prospectors learn prospecting skills, provides a contribution for working a mineral claim, and assists them in marketing their properties. Although the idea of prospector assistance is not new, the current program, which began in 1997, is different than previous prospector programs.

Prospector assistance programs began in the early 1990s as part of the Canada-Nova Scotia Cooperation Agreement on Mineral Development (CAMD). The Prospector Assistance Program under the most recent CAMD (1992-1995) was one of the agreement's most popular programs and the results were gratifying. There are now over 640 registered prospectors with approximately 240 companies or individuals holding one or more mineral licences in the province. Approximately 150 prospectors received assistance grants for work on their properties between 1992 and 1995. During the same time more than 200 people completed the Basic Prospecting Course and 12 attended the first offering of the Advanced Prospecting Course.

The cooperation agreements also provided limited financial assistance to attend trade shows for marketing mineral properties. Many prospectors attended the annual Prospectors and Developers Association of Canada meeting in Toronto and were able to interest companies in their properties.

The current Prospector Assistance Program (PAP) builds on this past experience. The department has brought together all parts of prospector assistance into one program instead of several. The program is funded by the Canada-Nova Scotia Economic Diversification Agreement, which is jointly administered by the Nova Scotia Department of Economic Development and Tourism and the Atlantic Canada Opportunities Agency (ACOA). The agreement has a value of $600 000 over fours years and will end in 2001. Table 1 provides the budget for each component of the PAP.

The Prospector Assistance Program has three components: (1) prospector training, (2) prospector assistance, and (3) marketing assistance. Although each component is independent of the others, all three are integrated to encourage development of the province's mineral potential.

Prospector training provides support for training entry-level prospectors in different locations throughout Nova Scotia. An advanced course is offered as demand warrants and gives additional experience to those prospectors who have graduated from the basic course. Table 2 lists the locations of courses in the past several years.

Financial assistance under the prospector assistance component provides a base level of support for individual prospectors to search for new mineral deposits and attract exploration activity by larger companies. Both the prospector and the program contribute toward this component. If a prospector has an application approved for the maximum amount of $5000, then he or she is required to contribute a minimum of $1500 to the project. Table 3 shows the number of assistance contributions and the target minerals.

The third component is marketing assistance for promoting and marketing mineral claims. Most of the marketing work is conducted at national and international trade shows. These provide an unparalleled opening to present Nova Scotia's mineral potential and investment opportunities to mining companies and industry representatives. Marketing assistance for prospectors provides financial assistance to travel to trade shows, to display information and show samples, and to make contacts with industry people. Table 4 lists the various trade shows and the number of prospectors attending in the first two years of the program.

The Prospector Assistance Program has been successful in obtaining the support of the prospecting community. Shortly after the program was made official in August 1997, the Mineral and Energy Resources Division hosted a workshop for stakeholders. Representatives of the prospecting community at large, the Prospectors Association of Nova Scotia, the Mining Society of Nova Scotia, and the Chamber of Mineral Resources of Nova Scotia met with division staff to review the guidelines and operating procedures of the

Table 1. Budget for the Prospector Assistance Program.

Component	Year 1 1997-98	Year 2 1998-99	Year 3 1999-00	Year 4 2000-01	Component Total
1. Training	$15 000.00	$25 000.00	$20 000.00	$20 000.00	$80 000.00
2. Assistance	$20 000.00	$100 000.00	$140 000.00	$140 000.00	$400 000.00
3. Marketing	$30 000.00	$30 000.00	$30 000.00	$30 000.00	$120 000.00
Yearly Totals	**$65 000.00**	**$155 000.00**	**$190 000.00**	**$190 000.00**	
				Total Amount of PAP	**$600 000.00**

Table 2. Location of prospecting courses.

Year	Basic Course	Advanced Course
Fall 1997	Port Hawkesbury, Halifax	Not offered
Spring 1998	Sydney, Halifax, Bridgewater	Halifax
Fall 1998	Stellarton, Halifax	Not offered
Spring 1999	Windsor, Sydney	Stellarton

Table 3. Summary of prospector assistance component applications.

Calendar Year	PAP Year	Number of Prospectors	Target Minerals
1997	Year 1, 1997-98	0	No prospector assistance component funding
1998	Year 2, 1998-99	22	vein and disseminated gold; paleoplacer gold; kaolin; base metals
1999	Year 3, 1999-00	28	vein and disseminated gold; paleoplacer gold; barite/fluorite; base metals; kaolin

program. The department launched the program at the annual Review of Activities in November 1997.

Prospectors have been enthusiastic in supporting the program. Each of the prospector training courses has been filled and many of the graduates have staked claims. Interest in prospector assistance contributions was so great in 1998 that we could only fund the first 22 applicants from a total of 36. Table 4 illustrates that prospectors have appreciated the support for marketing their properties. In the first two years of operation, 34 prospectors have received financial assistance to travel to trade shows and market their mineral properties or products.

Another measure of success is how the mineral industry views the properties offered at various trade shows. Companies in Australia, South Africa, the United States and Canada have expressed interest in the properties marketed by Nova Scotia prospectors, either through the publication *Properties for Option in Nova Scotia* or at trade shows. Some of the interest has resulted in option agreements.

Table 4. Trade shows attended by prospectors.

Date PAP Year	Location	Trade Show; Types of Properties	Number of Prospectors
January 1998 Year 1 1997-98	Vancouver	British Columbia and Yukon Chamber of Mines Cordilleran Roundup; disseminated and vein gold	3
March 1998 Year 1 1997-98	Toronto	Prospectors and Developers Association of Canada; paleoplacer gold, vein gold, base metals, rare earths	14
January 1999 Year 2 1998-99	Vancouver	British Columbia and Yukon Chamber of Mines Cordilleran Roundup; paleoplacer gold, barite/fluorite, base metals	4
January 1999 Year 2 1998-99	Toronto	Landscape Ontario trade show; various styles and sizes of shaped granite cobbles and granite tiles	1
March 1999 Year 2 1998-99	Toronto	Prospectors and Developers Association of Canada; vein and disseminated gold, base metals, barite	12

Prospecting is the grass roots of the mineral industry. Without a trained and motivated community of prospectors, many of the mineral discoveries that we need for future production will not be made. In this sense, prospectors are the future of the industry. In Nova Scotia, the Prospector Assistance Program provides the nourishment to sustain prospecting and the mineral industry.

Minerals Education Program: a program with continuing purpose

H. V. Donohoe, Jr.

Scope and Purpose

The Minerals Education Program (MEP) is a program of education and public awareness about minerals, geology, and the mineral industry in Nova Scotia. The audience for the program is drawn from residents and visitors, teachers and students, service clubs, chambers of commerce and boards of trade, land-use planners and managers, museums, government officials, and decision-makers at all levels. This program has a varied scope which includes describing the mineral industry in terms of geology and earth resources, mineral exploration, mining, reclamation, environmental sensitivity, sustainable development, land-use planning, mineral-based manufacturing, and economic development. Its purpose is to inform, advise, and educate many audiences about mineral, geological and fossil resources that affect life in Nova Scotia.

A Brief History

Mineral education has a long history within the Nova Scotia Department of Natural Resources (DNR) and earlier departments. During the 1950s, under the direction of former Deputy Minister J. P. Messervey, staff of the department and Messervey created simplified geological maps, films, and still photographs of mining operations, geological features and publications for the general public. His purpose was to publicize to a broad audience information about the geology and minerals found in the province, mining locations, and the uses for mineral products in everyday life.

The former Nova Scotia Department of Mines continued Messervey's work after his retirement by introducing prospector training and preparing various types of maps and publications for use by teachers, students and the general public. By the early 1980s, mineral education was regarded as important enough to assign a full-time person to developing and delivering components of the program.

From the mid-1980s to the mid-1990s, mineral education had strong financial and administrative support from three successive mineral development agreements (MDA). In each agreement, communicating with various audiences about the MDA, the mineral industry, and the importance of minerals received substantial funding. With the end of MDA funding, the department continues to support mineral education through its A-base budget.

Components of the Program and Current Activities

The scope of the work in the MEP falls into five areas of program responsibility. These are education and public awareness, information, training, policy issues, and liaison with groups. Activities associated with these areas are shown in Table 1.

Table 1. Minerals Education Program components and activities.

MEP Component	1998-99 Activities
1. Education and Public Awareness	•EdGeo Workshop about earth science resources for Nova Scotia teachers •Interpretive walks in provincial parks and other areas •Talks to service clubs and geology classes •Mining Week '98 activities •Work with boards of trade and chambers of commerce
2. Information	•Answer public inquiries about earth science and mineral resources •Write feature articles for *Nature's Resources* •Write articles and a column for *Minerals Update* •Staff displays •Prepare printed material •Answer industry inquiries •Provide information to DNR regional staff
3. Training	•Prospectors at seminars and field trips •General public in prospecting courses •Teachers at EdGeo Workshop •Teachers at the annual Association of Science Teachers in service day •University students at annual Nova Scotia Universities Field School •DNR staff in field offices and Middle Musquodoboit Education Centre
4. Policy Issues	•Mineral promotion •Land access for mineral resource development •Mineral, rock and fossil collecting •Economic development though mineral industry activity •Communications strategy about minerals for special groups
5. Liaison with Groups	•Mining Week Organizing Committee •Minerals Sector, Voluntary Planning •Chamber of Mineral Resources of Nova Scotia •Mining Society of Nova Scotia •CIM Halifax 2003 organizing group

Industrial Mineral activities, 1998

P. W. Finck

Introduction

Exploration for and production of industrial minerals continued to be a mainstay of the onshore mining industry in Nova Scotia during 1998.

Production of gypsum, salt, aggregate and cement continued to be strong during 1998, reflecting the historically stable nature of these industries. Equally promising was a strong interest in non-traditional industrial mineral commodities. Well over half of all exploration expenditures were directly related to the search for new industrial mineral commodities. Preliminary data also indicate that well over half of all ground under licence in the province was held for exploration activities related to industrial minerals.

Interest has remained strong in traditional areas such as gypsum and limestone. However, by far the greatest exploration interest has been directed toward non-traditional industrial minerals such as kaolin, salt for underground oil and gas storage, zeolites, titanium, and rare earth elements. Continued activity relating to kaolin accounted for nearly half of all exploration expenditures.

Activities

During 1998 I acted as the main initial contact for advice and information concerning industrial mineral resources. Numerous inquiries were received covering a wide variety of commodities. These inquiries were handled personally or directed to other staff with additional expertise relating to the commodity in question. In keeping with industry requests for confidentiality, specifics of these inquiries, activities or identified end uses will not be discussed. However, a general outline (not complete) of the types of commodity requests received and their common applications are given in Table 1.

In addition to responding to industry requests for assistance and information, minor field activity was undertaken. Of particular interest is the industrial mineral potential of leucogranite and leucomonzogranite of the South Mountain Batholith. These rocks tend to have high silica, feldspar and muscovite contents and low iron (predominantly occurring as biotite) concentrations. The rock is processed first by crushing, followed by selective flotation and finally high intensity magnetic separation to produce feldspar, muscovite and silica ore. A number of representative samples were collected during 1998 for preliminary process testing. Results of this testing are not yet known.

Mining of similar granitic rock types in the United States is rapidly replacing the traditional mining of pegmatites for these industrial minerals. Feldspar and silica are predominantly used in the glass and ceramics industries, and muscovite is finding increasing usage as a high value-added functional filler in flexible plastics used in the manufacture of automobile panels.

Table 1. Partial list of commodity information requests during 1998 and common uses of these commodities.

Commodity	Common Use
Andalusite	Refractory
Kaolin	Paper, paint, plastics, ceramics
Silica sand	Abrasive, glass, filler-extender
Limestone	Cement, agriculture, filler-extender
Gypsum	Wallboard
Granite, limestone, slate, sandstone	Dimension stone applications and aggregate
Common clay	Ceramics and construction
Diatomaceous earth	Functional filler
Montmorillonite (bentonite)	Drilling mud, cat litter, filter agent
Quartz stone	Landscaping
Barite	Drilling mud, other value-added products
Fluorite	HF acid, industrial/metallurgical applications
Kyanite	Refractory
Peat and peat bogs	Agriculture, horticulture
Sand	Agricultural applications
Rare earth elements	Special industrial applications, e.g. magnets

Digital Information Services

B. Fisher and J. Poole

The Digital Information Services group is responsible for developing and maintaining the branch Geographic Information System (GIS) and associated databases, the NovaScan bibliographic geoscience database, for supplying digital data and services to clients and staff, and for developing the branch internet web site. Permanent Digital Information Services staff consists of Brian Fisher and Jeff Poole, both of whom are geologists and GIS specialists, and Susan Saunders, a word processing operator. Krista Fraser, a GIS specialist, and Gayle Chapman, a geology student, are working with the group on a casual basis. Janette Vavra, formerly with this group, left the department in May 1998 and was replaced by Jeff Poole.

Digital Geoscience Data Products

A collection of digital geoscience datasets (in DXF, ARC export format, or as TIFF images in a UTM projection using the NAD27 datum) on Nova Scotia has been developed and is now on sale through the library. These datasets include digital geology maps, databases and images. The complete list of digital data products available can be seen in Appendix 3. This list can be obtained from the Halifax Library of the Nova Scotia Department of Natural Resources (DNR) or viewed on the Minerals and Energy Branch website at http://www.gov.ns.ca/natr/meb/pubshome.htm. A licence agreement is issued with all digital datasets. This agreement allows unrestricted use of the data with the understanding that Department of Natural Resources remains the owner of the data and is not transferring copyright to the buyer.

Public Access GIS

A public access GIS has been developed for use by clients in the Halifax Library. This is a user-friendly query and display system which uses a customized version of ArcView® to access a variety of geographically referenced digital geoscience data. It can display and query datasets, overlay various themes of geoscience, topographic and land-use information, and output the resulting maps as coloured plots. Staff are currently working on version 2 of the public access GIS which will contain new themes, an improved menu system, labelling capabilities and many other new features. This should be available in early 1999.

World Wide Web Site

The Minerals and Energy Branch has developed its own web site, which can be found at the following address: http://www.gov.ns.ca/natr/meb. In addition to providing information about branch staff and programs, the site also provides the latest *Publication Release Notices*, *Publications and Digital Data for Sale* lists, all the issues of the branch newsletter *Nova Scotia Minerals Update*, a *What's New* page, a copy of *Minerals, a Policy for Nova Scotia 1996*, *Selected Base Metal and Industrial Mineral Publications*, a review of *Mining Activities in Nova Scotia*, and a *Topics* page.

NovaScan

NovaScan is the bibliographic geoscience database on Nova Scotia and its offshore regions. As of December 31, 1998, the database contained 14,335 DNR records, consisting of 6202 mineral exploration assessment reports, 3411 publications, 1270 journal literature references, 1263 open file maps, 1196 open file reports, 72 open file illustrations, 756 theses, 148 contribution series, 5 outside publications, and 12 digital publications. Custom searches of the NovaScan database for clients will be done on request. Work is currently underway to make NovaScan accessible to clients through the public access GIS. This should be available in early 1999.

GIS Projects

The Digital Information Services staff have also been working cooperatively with branch staff and some other organizations on several projects.

Mineral Resource Land-use Digital Atlas

In conjunction with land-use staff, we are continuing to convert the 'Mineral Resource Land-use Atlas' for Nova Scotia into digital form.

Surficial Geology Project

In cooperation with the surficial geologists an ArcView® application was developed which will be used to compile data collected as part of a new 1:50 000 surficial geology mapping project.

New Bedrock Geology Map of Nova Scotia

The new 1:500 000 scale *Geology Map of Nova Scotia* is nearing completion and will be integrated into the GIS. It is hoped that the new map will be available by mid-1999.

Registry Database

Work on integrating the Registry of Mineral and Petroleum Titles database into the GIS and automating the production of the *Mineral Claims Disposition Map* has been completed. This database will be available in the new version of the public access GIS.

Composite Geology Map of Nova Scotia

Work on a new composite geology map of Nova Scotia continued through the year by Gayle Chapman and Michelle Williamson. Using AutoCAD® and Fieldlog®, work has been completed on the initial digitizing and verification of 45 geology maps, including the geological line work and over 60 000 data points and their attributes. These maps and databases will be included in the GIS and made available through the public access GIS over the next year.

Gold District Plans

A new project, to digitize the line and point information for 30 Faribault gold district maps was started by Gayle Chapman. She has completed the initial digitizing and is now in the process of verifying the data. Following this, the data will be put into our GIS, the maps will be geo-referenced, and then added to the public access GIS.

1:50 000 Shaded Relief Digital Elevation Model Project

Krista Fraser developed an application to produce shaded relief images and hard copy maps from a 1:50 000 Digital Elevation Model (DEM) which was developed by Tim Webster at the Nova Scotia College of Geographic Sciences (COGS).

1:10 000 Digital Elevation Model and Watershed Project

This project was initiated with the cooperation of the Nova Scotia Geomatics Centre, Department of Agriculture and Marketing, DNR Forestry Division, and DNR Wildlife Division. Krista Fraser is developing a GIS application to produce hydrologically correct DEMs from the 1:10 000 scale topographic base maps, and then produce watershed maps. Phase one, the development of the application, will be completed by March 31, 1999, and will test the application in one or more geographic areas to determine requirements for the viability of creating DEMs and watersheds for the whole province.

Internet Map Server

Jeff Poole, who has experience developing internet map servers, is currently investigating the feasibility of creating an internet map server that will allow our clients to view, query, plot and download our digital maps and databases over the internet.

Canadian Geological Knowledge Network (CGKN)

As a result of an initiative launched through the National Geological Surveys Committee, the Minerals and Energy Branch is also working cooperatively with the Geological Survey of Canada and other provincial minerals and energy departments across Canada to investigate the possibility of creating an internet-based Canadian Geological Knowledge Network (CGKN). The objective of this initiative is to provide access to all provincial and federal geoscience data through one internet web site. The initial meeting and workshops to discuss the CGKN concept were held in Ottawa in December 1998 and were attended by Scott Swinden and Brian Fisher.

Musquodoboit Batholith Project: geological mapping of the Musquodoboit Harbour area (NTS 11D/14)

L. J. Ham

Introduction

The Musquodoboit Batholith is the second largest granitoid pluton (~800 km^2) in the Meguma Terrane of mainland Nova Scotia (Fig. 1). The batholith intruded Cambro-Ordovician metasedimentary rocks of the Meguma Group during the Devonian Acadian Orogeny (ca. 370 Ma; Clarke and Halliday, 1980; Reynolds *et al.*, 1981). The body roughly parallels the coastline, extending east of Halifax to Sheet Harbour, and covers parts of three National Topographic System (NTS) map areas, 11D/13, 11D/14 and 11D/15.

Bedrock mapping of the batholith was initiated to compare and contrast its lithology and mineralogy with the larger (~7300 km^2) South Mountain Batholith of southern Nova Scotia (Fig. 1). Results of the mapping project were plotted digitally on 1:10 000 scale maps which were subsequently merged (maps and databases) to create 1:50 000 scale maps. Portions of the batholith outcropping on NTS map area 11D/13 have been illustrated in two open file maps released in 1998 (Open File Maps 1998-5 and 1998-9). This report discusses results of mapping on NTS 11D/14 and illustrates those results in Figure 2. NTS map area 11D/15 is currently in

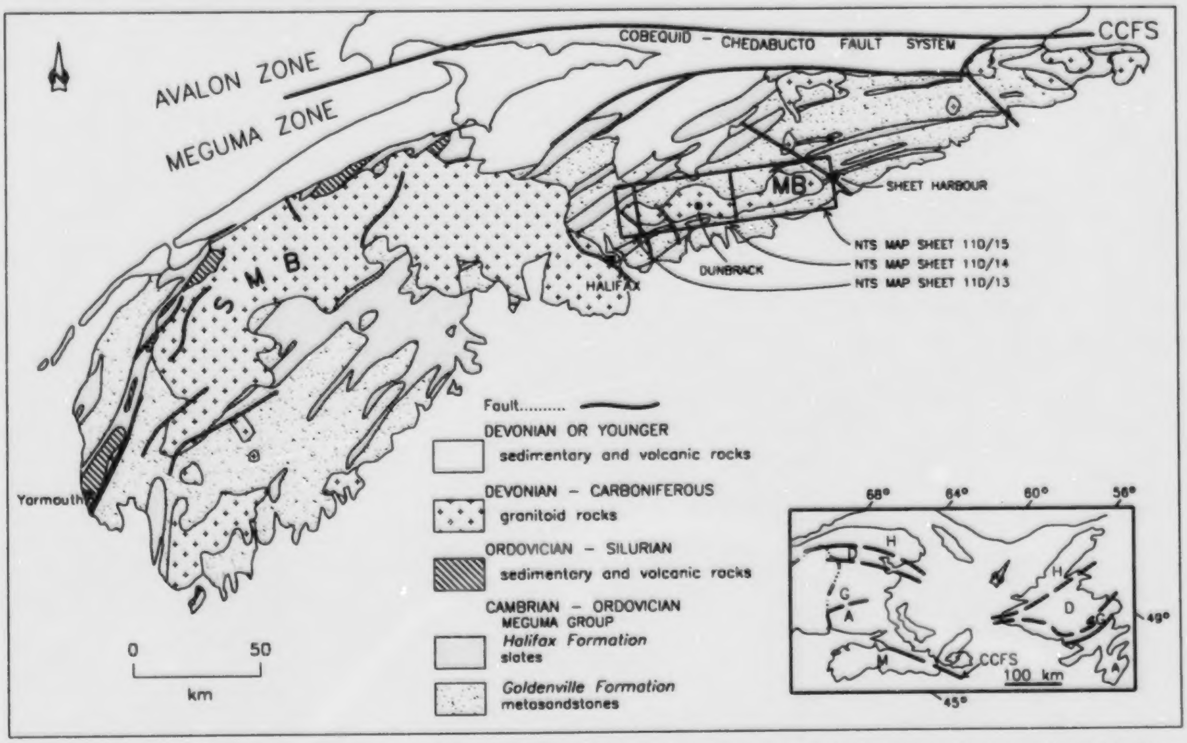

CCFS
COBEQUID – CHEDABUCTO FAULT SYSTEM
AVALON ZONE
MEGUMA ZONE
MB
SHEET HARBOUR
S. M. B.
HALIFAX
DUNBRACK
NTS MAP SHEET 11D/15
NTS MAP SHEET 11D/14
NTS MAP SHEET 11D/13
Yarmouth
Fault..........
DEVONIAN OR YOUNGER
sedimentary and volcanic rocks
DEVONIAN – CARBONIFEROUS
granitoid rocks
ORDOVICIAN – SILURIAN
sedimentary and volcanic rocks
CAMBRIAN – ORDOVICIAN
MEGUMA GROUP
Halifax Formation
slates
Goldenville Formation
metasandstones
0
50
km
68°
64°
60°
56°
49°
45°
H
G
A
D
M
CCFS
100 km

Figure 1. Simplified geological map of the Meguma Zone showing the location of the Musquodoboit Batholith (MB) and the South Mountain Batholith (SMB). The boundary between the Meguma and Avalon zones is marked by the Cobequid-Chedabucto Fault System (CCFS). Abbvreviations on the inset map are: Avalon Zone (A), Dunnage Zone (D), Gander Zone (G), Humber Zone (H) and Meguma Zone (MZ), representing zones of the Appalachians from Williams (1979).

the final stages of completion; these two maps and the final project report will be released in 1999.

Previous Work

The boundaries of the batholith were outlined by Fletcher and Faribault (1887); however, no attempt to re-map the batholith was undertaken until the 1970s, when McKenzie and MacGillivary (1974) did work as part of a larger project comparing granites along the Eastern Shore, followed by Jones and MacMichael (1976) who mapped a portion of the batholith. MacDonald (1981) studied the entire batholith as part of an M.Sc. thesis at Dalhousie University and subsequently reported on the results (MacDonald and Clarke, 1985).

Results of Mapping

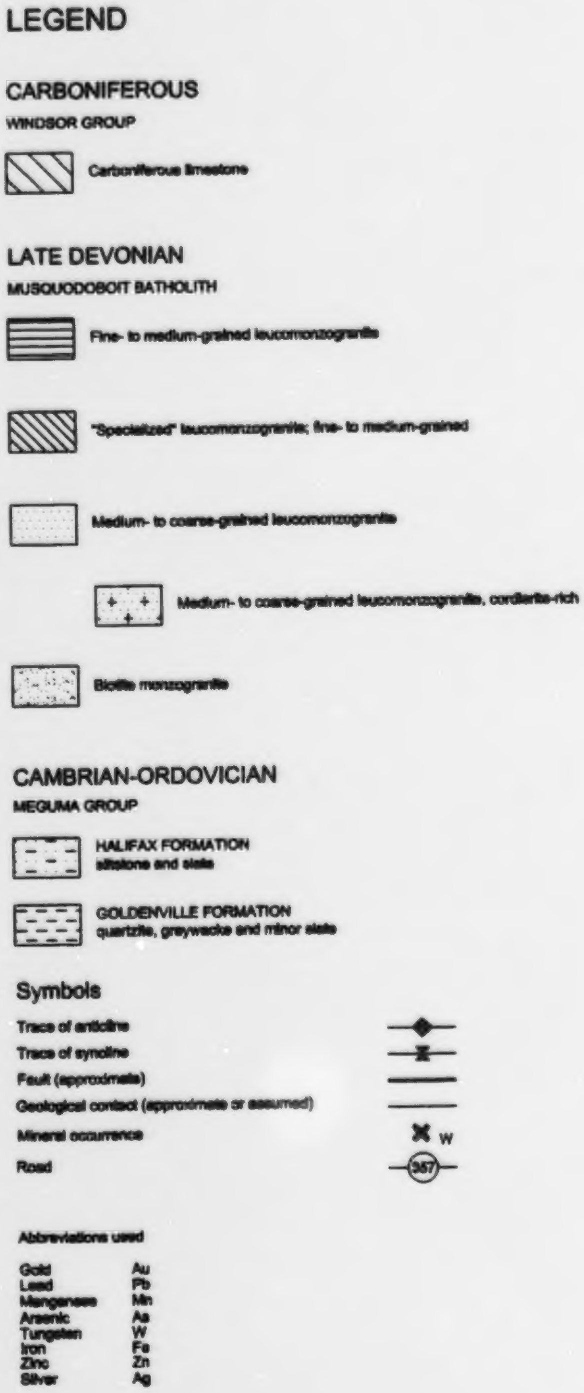
The units are subdivided following the methodology and terminology used in the 1984-1989 South Mountain Batholith Project (e.g. MacDonald *et al.*, 1992). Based on field mapping, geochemistry and thin section petrography, the Musquodoboit Batholith can be subdivided lithologically into four distinct units, similar to some of those found in the South Mountain Batholith. These units are described below in the assumed order of oldest to youngest, based on cross-cutting relationships and geochemistry, and illustrated in Figure 2.

Medium to Coarse-grained Biotite Monzogranite

The apparently oldest rock type is a buff-white and pink, medium- to coarse-grained (locally K-feldspar megacrystic) biotite monzogranite. This unit contains biotite (6-12%), muscovite (trace - 1%) and cordierite (trace - 1%). Monzogranite occurs in two narrow bodies adjacent to the observed contact with metasedimentary rocks of the Meguma Group (Fig. 2). Localized areas within the medium- to coarse-grained leucomonzogranite contain increased amounts of biotite, such as near the eastern side of map area 11D/14. These rocks are classified as biotite monzogranite, but are exposed over limited areas and are not illustrated on the map.

Medium- to Coarse-grained Leucomonzogranite

The most abundant rock type in the batholith is buff-white to pink, medium- to coarse-grained (locally K-feldspar megacrystic) biotite leucomonzogranite. It is


LEGEND
CARBONIFEROUS
WINDSOR GROUP
Carboniferous limestone
LATE DEVONIAN
MUSQUODOBOIT BATHOLITH
Fine- to medium-grained leucomonzogranite
"Specialized" leucomonzogranite; fine- to medium-grained
Medium- to coarse-grained leucomonzogranite
Medium- to coarse-grained leucomonzogranite, cordierite-rich
Biotite monzogranite
CAMBRIAN-ORDOVICIAN
MEGUMA GROUP
HALIFAX FORMATION
siltstone and slate
GOLDENVILLE FORMATION
quartzite, greywacke and minor slate
Symbols
Trace of anticline
Trace of syncline
Fault (approximate)
Geological contact (approximate or assumed)
Mineral occurrence
W
Road
357
Abbreviations used
Gold Au
Lead Pb
Manganese Mn
Arsenic As
Tungsten W
Iron Fe
Zinc Zn
Silver Ag

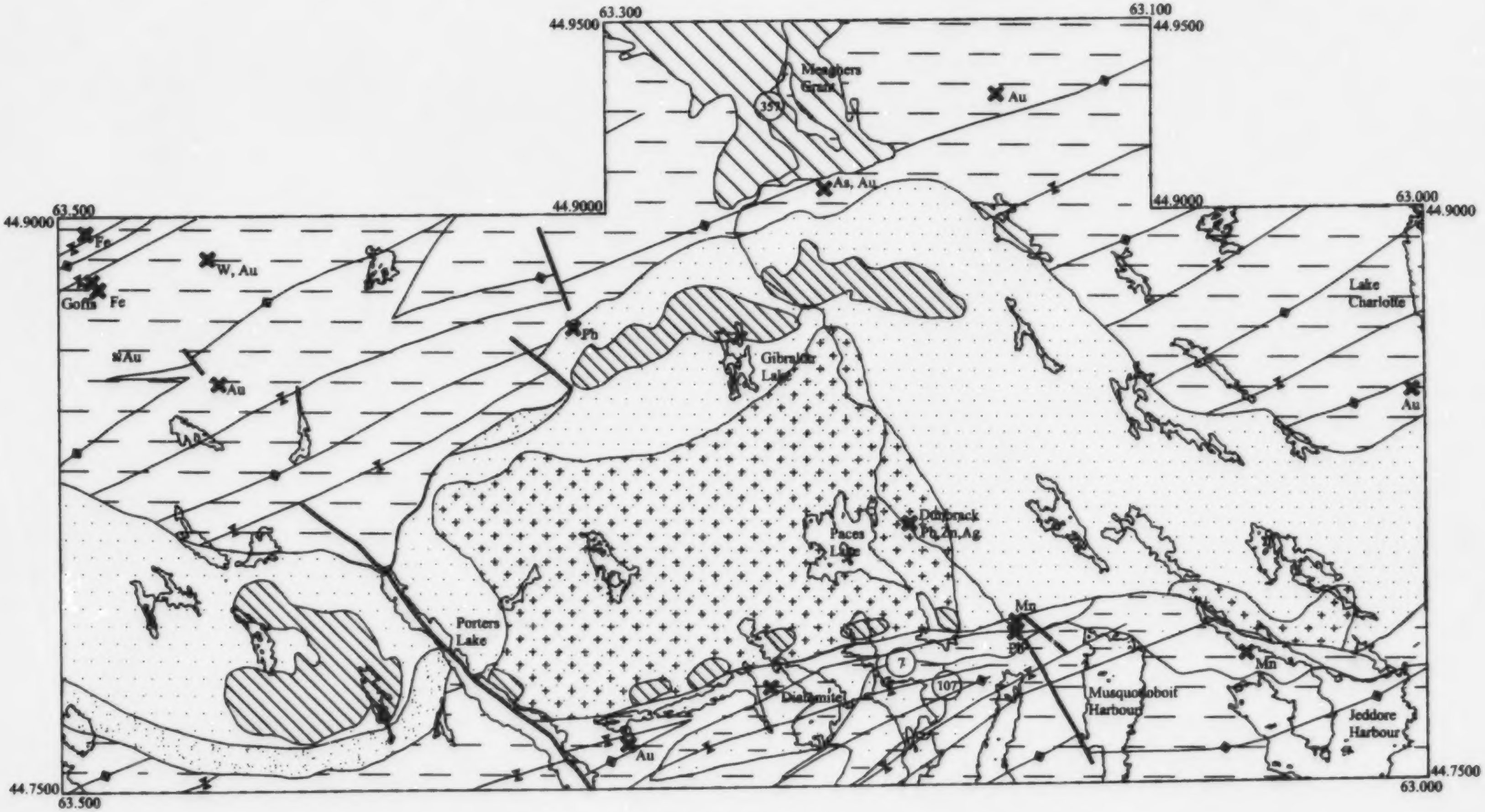

63.300
44.9500
63.100
44.9500
Meaghers Grant
357
Au
As, Au
44.9000
44.9000
63.500
44.9000
63.000
44.9000
Fe
W, Au
Goffs
Fe
Pb
Au
Au
Gibraltar Lake
Lake Charlotte
Au
Dutchnack
Pb,Zn,Ag
Paces Lake
Porters Lake
Mn
Pb
7
107
Mn
Dollamite
Musquodoboit Harbour
Jeddore Harbour
Au
44.7500
63.500
44.7500
63.000

Figure 2. Simplified geology map and legend (preceding page) of NTS map area 11D/14.

mineralogically similar to the biotite monzogranite, but contains less biotite (4-8%, average 6%). This unit differs from the SMB leucomonzogranite which has 3-10% mucovite; in leucomonzogranite of the Musquodoboit Batholith muscovite occurs only in trace amounts. Cordierite is generally present (trace - 2%) in all leucomonzogranitic rocks. Two areas of leucomonzogranite have increased modal percentages of cordierite (up to 4%) and have been designated with a separate pattern (Fig. 2). Euhedral, blocky cordierite grains range in size from 0.3 - 1 cm in length. The largest area underlain by these cordierite-rich rocks (between Porters Lake and Paces Lake) was outlined in part by previous workers (Jones, 1975; MacDonald, 1981) and the contacts have been refined. The second, smaller area occurs along the margin of the batholith, adjacent to the contact with metasedimentary rocks north of Jeddore Harbour (Fig. 2).

Specialized Leucomonzogranite

This unit occurs in several areas of the Musquodoboit Batholith and typically consists of texturally and mineralogically variable leucomonzogranite. Grain size ranges from fine- to medium-grained and texture varies from equigranular to porphyritic and pegmatitic. Airborne gamma-ray spectrometric surveys identified some of these rocks as having high equivalent uranium/equivalent thorium ratios (eU/eTh; Ford, 1991; Ham, 1993). These bodies were further defined by geological mapping and are shown in Figure 2.

The area of specialized leucomonzogranite located west of Porters Lake (Fig. 2) has high muscovite (2-4%) contents, low (trace -2%) biotite contents, and is generally medium- to coarse-grained with some textural variability (e.g. fine grained, aplite) noted on individual outcrops. The two specialized leucomonzogranite bodies in the centre of the batholith north of Gibraltar Lake (Fig. 2) generally exhibit more textural variability than seen west of Porters Lake. They are finer grained and local areas have pronounced porphyritic texture (phenocrysts of K-feldspar, larger grains of biotite, rosettes of muscovite). Five small (~1 km^2) bodies of specialized leucomonzogranite occur along the southern margin of the batholith. These bodies are characterized by finer grain size and one body exhibits porphyritic texture.

Fine- to Medium-grained Leucomonzogranite

This unit occurs in one locality on the eastern shore of Paces Lake (Fig. 2) and consists of a buff-white to pink and red, fine- to medium-grained, equigranular to slightly porphyritic, massive leucomonzogranite. This rock was not outlined by the airborne gamma-ray spectrometric survey (Ford, 1991) as a specialized leucomonzogranite. Work by Kontak (1997) on the Dunbrack Pb-Cu-Zn-Ag deposit (Fig. 2), located to the southeast of this body, suggests that the dyke hosting the Dunbrack mineral occurrence is on strike (110°/62°N) with this equigranular leucomonzogranite, although the dyke was not traced in outcrop.

Summary

The Musquodoboit Batholith can be classified using the same terminology used for the South Mountain Batholith, although the medium- to coarse-grained leucomonzogranite is comparitively muscovite-poor in the Musquodoboit Batholith. The rock types are medium- to coarse-grained biotite monzogranite, medium- to coarse-grained biotite and biotite-cordierite leucomonzogranite, specialized leucomonzogranite, and fine- to medium-grained leucomonzogranite (which occurs in only one locality). The majority of the batholith underlying NTS map area 11D/14 consists of the medium- to coarse-grained leucomonzogranite and contains cordierite (trace - 2%), in addition to biotite (average 6%) and trace amounts of muscovite. Two areas within this unit are relatively enriched in cordierite (up to 4%). Biotite-rich rocks (average 8% biotite) occur discontinuously along the southern Meguma Group metasedimentary/granite contact west of Porters Lake, and in a narrow unit along the northern contact east of Porters Lake. Similar findings were discussed in the eastern portion of the batholith and in the Tangier Grand Lake area (NTS 11D/15; Ham, 1998).

Additional division of the leucomonzogranitic rocks was based on texture (porphyritic, pegmatitic, aplitic, equigranular) and mineralogy (abundances of muscovite, biotite). These granites were outlined as high ratio granites, following the work of Ford (1991), who suggested that these rocks have an eU/eTh ratio greater than 1.

References

Clarke, D. B. and Halliday, A. N. 1980: Strontium isotope geology of the South Mountain Batholith, Nova Scotia; Geochemica et Cosmochemica Acta, v. 44, p. 1045-1058.

Ham, L. J. 1993: A progress report on the Musquodoboit Batholith Project; *in* Mines and Minerals Branch Report of Activities 1992, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Report 93-1, p. 45-59.

Ham, L. J. 1998: Musquodoboit Batholith Project and the geology of the Tangier Grand Lake area; *in* Minerals and Energy Branch Report of Activities 1997, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Report 1998-1, p. 3-10.

Horne, R. J., Baker, D. E. and Ham, L. J. 1998: Geological map of Waverley (part of NTS sheet 11D/13), Halifax County, Nova Scotia; Nova Scotia Department of Natural Resources, Open File Map ME 1998-9, scale 1:10 000.

Feetham, M., Horne, R. J., Baker, D. E. and Ham, L. J. 1998: Geological map of Soldier Lake (part of NTS sheet 11D/13), Halifax County; Nova Scotia, Nova Scotia Department of Natural Resources, Open File Map ME 1998-5, scale 1:10 000.

Ford, K. L. 1991: Radioelement mapping of parts of the Musquodoboit Batholith and Liscomb Complex, Meguma Zone, Nova Scotia; *in* Mineral Deposit Studies in Nova Scotia, v. 2, ed. A. L. Sangster; Geological Survey of Canada, Paper 91-9, p. 71-111.

Jones, B. E. and MacMichael, T. P. 1976: Observations of the geology of a portion of the Musquodoboit Harbour Batholith; Nova Scotia Department of Mines and Energy, Report 76-2, p. 63-71.

Kontak, D. J. 1997: Mineralogical and geochemical studies of the Dunbrack Pb-Cu-Zn-Ag deposit, Musquodoboit Batholith, southern Nova Scotia; *in* Minerals and Energy Branch Report of Activities 1996, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Report 97-1, p. 73-86.

MacDonald, M. A. 1981: The mineralogy, petrology and geochemistry of the Musquodoboit Batholith; unpublished M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia, 272 p.

MacDonald, M. A. and Clarke, D. B. 1985: The petrology, geochemistry, and economic potential of the Musquodoboit batholith, Nova Scotia; Canadian Journal of Earth Sciences, v. 22, p. 1633-1642.

MacDonald. M. A., Horne, R. J., Corey, M. C. and Ham, L. J. 1992: An overview of recent bedrock mapping and follow-up petrological studies of the South Mountain Batholith, southwestern Nova Scotia, Canada; Atlantic Geology, v. 28, p. 7-28.

Reynolds, P. H., Zentilli, M. and Muecke, G. K. 1981: K-Ar and ^{40}Ar/^{39}Ar geochronology of granitoid rocks from southern Nova Scotia: its bearing on the geological evolution of the Meguma Zone of the Appalachians; Canadian Journal of Earth Sciences, v. 18, p. 386-394.

Williams, P. F. 1979: Appalachian Orogen in Canada; Canadian Journal of Earth Sciences, v. 16, p. 792-807.

Mineral Resource Land-use Information and Policy

D. B. Hopper and F. J. Bonner

The Land-use Group consists of a senior planner and a land-use geologist who provide the Minerals and Energy Branch with land-use information and policy, and planning services that relate to mineral resources. The Land-use Group provides a link between the provincial government's interests in geoscience and the public's need for geological and mineral resource information. Policy and regulatory analyses are conducted on land-use, resource and environmental planning and development initiatives, which have the potential to affect mineral exploration and development. Principal clients include interested stakeholders in the use of land and resources, such as other resource departments, municipal units, community economic development agencies, other non-government organizations and landowners. Activities in 1998 focused on (1) information services, (2) Integrated Resource Management (IRM), (3) policy reviews, and (4) review of the Miller Report.

Information Services

The Land-use Group prepares geological, mineral resource and land-use information, maps, reports and digital products, using a geographic information system (GIS), to facilitate land-use, resource and environmental planning and decision-making. The group also provides information to government and its clients on mineral resources, mineral use, mineral potential, land use, IRM, reclamation, mineral recycling and sustainable development. Maps and reports were prepared for geotechnical consultants, municipal and transportation planners and departmental staff. The information services can be grouped into several themes including: general inquiries, presentations, conferences, student project assistance, and special projects.

General Inquiries

The Land-use Group handles a wide range of information requests from the public, industry and government. Inquiries included information on acid drainage, aquifer and flood-risk mapping, watershed mapping, mineral resource assessments for candidate protected areas, land ownership status for prospectors, statistics on land area disturbed by mining in Canada, and geological and mineral resource mapping for the Department of Agriculture's Wetland Evaluation Screening Tool (WEST) project.

The Land-use Group is beginning to focus more on community economic development issues. Initial plans were discussed for organizing and presenting geological and mineral resource information to communities and local businesses. Several requests were handled that are closely related to community economic development such as geological information for international interests in horizontal drilling for lateral pipeline development in Nova Scotia, and community water supply and industrial development issues. One idea, by a Halifax-based company, involved the use of construction waste to neutralize acid drainage problems in abandoned and inactive slate pits.

Requests also came from the Department of Transportation and Public Works for mineral resource and geological information needed in new highway development projects. A route location process gathers key data to screen out constraints including geological hazards and conflicts with mineral resources, including current and potential activity. Three projects were provided with resource mapping information including one in New Minas, another in Beaverbank, and a proposed 100-series, 4-lane, controlled access highway connecting highways 102 and 103.

Presentations

The Land-use Group coordinated a series of papers presented to graduate students in resource and environmental studies at Dalhousie University. F. J. Bonner presented an overview of the role of geoscience in planning and decision-making. H. V. Donohoe focused on the main activities of exploration and mining and their economic effects in rural Nova Scotia. D. B. Hopper addressed the need to integrate mineral resource and land-use planning in Nova Scotia.

Presentations were also given to junior high school students at a 'Science and Technology Conference'. This involved explaining the role of a professional geologist and conducting a resource management module designed after the Jim Campbells Barren story.

Articles were written for *Minerals Update* on the subjects of land access and mineral resources in Nova Scotia and an update on the protected areas agenda.

Conferences

The Annual Canadian Land Reclamation Association (CLRA) conference, held in Toronto, was attended by F. J. Bonner. CLRA is a national organization associated with the American Society for Surface Mining Reclamation (ASSMR). Several presentations focused on mining-related projects, including a program for managing abandoned aggregate properties and community involvement programs in mine-site reclamation. Informal discussions about establishing a Nova Scotia Chapter of CLRA were initiated by the CLRA Executive.

Student Project Assistance

The Land-use Group provided advice to a number of student projects from the College of Geographic Sciences, Nova Scotia College of Art and Design (Environmental Planning), and Dalhousie University.

Special Projects

The Land-use Group also conducts special projects along the theme of minerals, geology and land-use planning. The development of a digital, thematic atlas (a set of interactive, digital maps covering the province at 1:50 000) called the 'Mineral Resource Land-use (MRLU) Atlas' continued this year . This is a compilation of digital, mineral-based inventories that are stored as thematic layers. These thematic layers show the location and distribution of mineral occurrences, sand and gravel deposits, coal seam traces, operating and abandoned mines, quarries and pits, old gold workings, drillholes, geomorphological features, geohazard indicators, mining leases and permits, and special land-use designations. This year about 90% of all MRLU data were transferred from hard-copy maps and made available in digital form. Final development of the MRLU digital atlas and a companion database will be undertaken during the summer of 1999.

Integrated Land-use and Resource Management

The need to integrate geological and mineral resource interests with other land-use and resource planning is clearly identified in the province's Mineral Policy, Nova Scotia's Sustainable Development Strategy, and the department's Integrated Resource Management (IRM) process. This year the Land-use staff continued to work with the regional IRM teams and the provincial IRM steering committee - the Integrated Resource Management/Land-use Committee (IRM/LUC).

The Land-use geologist worked with regional geologists in representing geological and mineral-based interests in the IRM process. All IRM overview and commitment layers for mineral resources were developed for the three regions. Two maps were compiled for the Eastern Region at a scale of 1:200 000, two maps for the Western Region at a scale of 1:125 000, and four for the Central Region at a scale of 1:125 000.

In support of developing the 'Base Case' for the Central Region's IRM process, eighteen mineral inventory maps were compiled at a scale of 1:125 000. These maps displayed known geological and mineral resource information including, geology, mineral occurrences, abandoned mine openings, pits and quarry locations, drillholes, surficial geology, water supply areas, and resource commitments such as petroleum licence blocks and mineral licences, mining leases and permits.

Municipal water supply areas in Halifax and Hants counties were also defined, updated and plotted on a series of IRM maps at a scale of 1:125 000. A similar set of maps are being planned for the Eastern and Western regions.

The senior planner continued to provide planning and process advice to the regional IRM teams as well as to the IRM/LUC. At the regional level this involved reviewing drafts of IRM overview documents from all regions and attending regional IRM meetings. Special assistance was provided to the Central Region IRM team by working through each step of the IRM planning process. The planner also acted as a resource person for the Central Region's public consultation sessions.

Writing the IRM planning framework document continued to be a major task of the senior planner. The main objective of the framework document is to provide a clear, easily understood description of the IRM process for the regional IRM planning teams. Drafts were sent to IRM/LUC members and the three regional IRM planning teams. Principle issues still to be resolved include the incorporation of an ecosystem-based management system, defining local area planning, and setting provincial resource objectives and indicators.

Policy Reviews

The Land-use Group reviews and advises on land-use matters and related policy initiatives as they affect the mineral industry. This involves monitoring, reviewing and advising on land, environmental and natural resource-based policy, planning and development initiatives. The objective is to ensure the protection of mineral resources, land access and mineral tenure for mineral exploration in Nova Scotia. Local land-use priorities, land access, tenure and environmental issues are also monitored and considered in mineral resource management, exploration, mining and reclamation programs. The group also participates in various intra- and inter-departmental land-use, environmental planning, and strategic development initiatives. This service includes reviews and commentary on environmental assessment documents as well as other development initiatives conducted by other departments.

This year the 'Municipal Government Act: a working paper in legislative form' was reviewed. Recommendations were made to forge communication links with the Department of Housing and Municipal Affairs to review Municipal Plans, to form an interdepartmental consultation process for developing statements of provincial interest, and to develop for statutory amendment one or more statements of provincial interest regarding natural resources.

Other reviews conducted involved the Department of Environment's Watershed Management Strategy; the Federal Government's Water Strategy and the Gully Conservation Strategy; the World Commission on Protected Areas policy on mining and associated activities in relation to protected areas; a Halifax Regional Municipality draft by-law regarding blasting regulations; municipal controls on pits and quarries, with special attention to the control over rock crushers; and provided input to a Land Access workshop held during the Mines Ministers' Conference in Calgary.

Environmental assessment registration documents reviewed included the Greenhills Coal Development project, Melford Gypsum Quarry, Coalburn Mining project in Thorburn, and the Berichan (Cottam Settlement) Project in Debert. Staff also coordinated the department's review of environmental assessment documents for the Halifax and Point Tupper pipeline laterals.

Miller Report Implementation Plan

In December 1997, Mr. George Miller was commissioned by the government of Nova Scotia to carry out a review of the structure and staff of the department's Minerals and Energy Branch. The review was completed at the end of March 1998, and the Miller Report outlined a number of recommendations to be considered by an implementation team.

Staff of the Land-use Group were assigned to the following two committees to discuss implementation of the Miller Report: a program review team, and a mineral development and policy team. Staff participated in the review of the Miller Report and proposed an alternative program structure for the Minerals and Energy Branch. Staff also participated in the development of a proposed Mineral Development and Policy (MDP) Group.

Geochemical profile of a carbonate-quartz alteration zone in footwall rocks of the Stirling VMS base metal deposit, Richmond County, Cape Breton Island

D. J. Kontak

Introduction

The Stirling massive sulphide deposit, located in southeast Cape Breton Island (Fig. 1), is a Zn-rich base metal deposit hosted by volcaniclastic rocks of the 680 Ma Stirling Group. Although initially discovered as a copper prospect in the 1890s, it was developed in the 1930s and 1950s as an underground massive sulphide mine with production of about 1.2 million tonnes of 6.4% Zn, 1.5% Pb, 0.74% Cu and 2.2 oz./t Ag and 0.03 oz./t Au (Miller, 1979). Since production ceased, exploration on the property and adjoining areas has continued intermittently over the past 40 years.

Because of the lateral continuity of the sulphide deposit, its location within a shear zone, and the appearance of replacement textures, the deposit was originally considered to have formed as a result of magmatic-related solutions ascending a shear or fault zone and replacing the host rock sequence (Alcock, 1930; Weeks, 1924, 1954; Watson, 1954, 1957). The base metal mineralization was re-interpreted as being related to exhalative processes in the 1970s (Poole, 1974; Miller, 1979) based on analogies with younger, less deformed massive sulphide deposits (e.g. Kuroko deposits of Japan) and new theories proposed for similar mineralization (see Franklin *et al.*, 1981, for review). However, an important aspect of the competing genetic models proposed for the Stirling deposit is interpretation of the origin of a quartz-talc-carbonate (QTC) rock that is intimately associated with mineralized zones throughout the deposit (Kontak, 1998). Originally considered to be an alteration halo in the epigenetic, vein model of early workers, Miller (1979) was the first to formally propose this lithology as an exhalative horizon and syngenetic with respect to the sulphide mineralization. However, whereas Miller interpreted the QTC rock to have formed as a result of exhalative processes on the ocean floor, recently Kontak (1998, 1999) suggested that most of this rock formed as a replacement of volcaniclastic rock beneath the sediment - ocean floor interface. More recently Kontak (1999) has suggested the QTC was deposited from low-temperature fluids (i.e. ca. 80-100°C) temporally and spatially related to the same geothermal system that generated the higher temperature (i.e. ca. 300°C), sulphide-depositing fluids.

Whereas generation of the low-temperature hydrothermal system is considered analogous to modern travertine deposits (e.g. Yellowstone Park, Wyoming), the high-temperature hydrothermal system is analogous to black smokers at modern vent sites on the ocean floor. The Stirling deposit is not unique in terms of the association of quartz-carbonate alteration with massive sulphide mineralization, as large sulphide deposits (i.e. several million tonnes) with somewhat similar association occur in the Proterozoic of the Sudbury area (e.g. Errington and Vermillion Zn-Cu-Pb deposits) and Bergslagen district of Sweden (Garpenberg deposit) (see Rousell *et al.*, 1997). Documentation of the nature, genesis and role of the QTC alteration is key to the understanding of the Stirling massive sulphide deposit.

The case for a replacement origin for QTC rock is based on results of logging drill core stored at the NSDNR Core Library in Stellarton, petrographic examination of these materials, and subsequent geochemical assays of drill core samples.

Geology of the Stirling Deposit Area

The Stirling deposit is located within the ca. 680 Ma Stirling Group, a sequence of mafic and felsic volcanic and volcaniclastic rocks of epiclastic origin interbedded with lenses of fine- to coarse-grained clastics composed of detritus derived from the volcanic rocks (Barr *et al.*, 1996). The Stirling Group was interpreted by Macdonald and Barr (1993) to have been deposited within and around a trough flanked by volcanic centres in an intra-arc setting of continental affinity. Relevant with respect to massive sulphide mineralization are observations that sedimentary structures (i.e. rip-up clasts, graded bedding, basal scours) within the sequence indicate subaqueous mass transport with deposition below

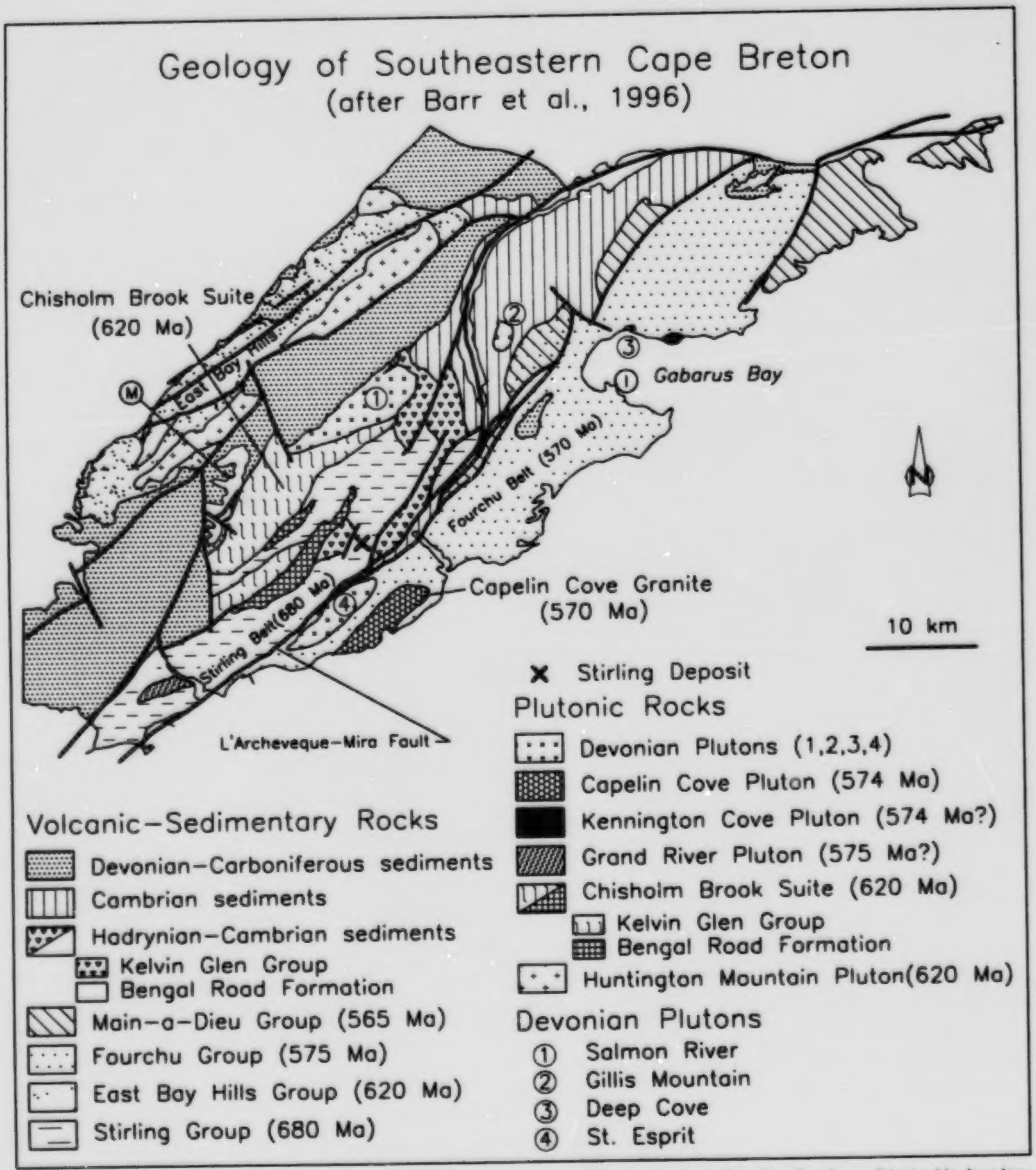

Geology of Southeastern Cape Breton
(after Barr et al., 1996)
Chisholm Brook Suite
(620 Ma)
East Bay Hills
M
1
2
3
Gabarus Bay
Fourchu Belt (570 Ma)
Capelin Cove Granite
(570 Ma)
4
Stirling Belt (680 Ma)
L'Archeveque–Mira Fault
N
10 km
× Stirling Deposit
Plutonic Rocks
Devonian Plutons (1,2,3,4)
Capelin Cove Pluton (574 Ma)
Kennington Cove Pluton (574 Ma?)
Grand River Pluton (575 Ma?)
Chisholm Brook Suite (620 Ma)
Kelvin Glen Group
Bengal Road Formation
Huntington Mountain Pluton(620 Ma)
Volcanic–Sedimentary Rocks
Devonian–Carboniferous sediments
Cambrian sediments
Hadrynian–Cambrian sediments
Kelvin Glen Group
Bengal Road Formation
Main–a–Dieu Group (565 Ma)
Fourchu Group (575 Ma)
East Bay Hills Group (620 Ma)
Stirling Group (680 Ma)
Devonian Plutons
① Salmon River
② Gillis Mountain
③ Deep Cove
④ St. Esprit

Figure 1. Regional geological map of southeast Cape Breton Island showing the distribution of Late Hadrynian volcanic-sedimentary packages and intrusive rocks with younger overlapping sequences and plutonic rocks. Location of the Stirling Zn-Pb-Cu-Ag-Au deposit is indicated within the 680 Ma Striling Group rocks.

wave base (Macdonald and Barr, 1993; Kontak, 1998, and herein). Although the felsic and mafic volcanic rocks show little evidence of subaqueous deposition, the interbedded sedimentary rocks provide evidence of such a setting.

Structurally, the Stirling Group is variably deformed, with northwest-southeast directed compression and northeast strike-slip movement, demonstrated by the highly strained, mylonitic zones that grade into less deformed areas over distances of tens of metres. The most intense deformation on a regional scale occurs proximal to the Mira-L'Archeveque Fault (Fig. 1); however, highly strained rocks also occur throughout the deposit area and are very common in drill core from the deposit. The presence of deformation is a hindrance to study of the QTC rock since this unit has preferentially taken up a lot of the strain in the deposit area and most primary textures have been destroyed.

The Stirling Group is intruded by and bounded to the north by the 620 Ma Chisholm Brook plutonic suite, but this intrusive complex has not affected rocks at the Stirling deposit. Near the deposit area Stirling Group rocks are overlain unconformably by coarse clastics of Late Hadrynian age (Fig. 1).

Deposit Geology

The geology of the Stirling deposit and surrounding area (Fig. 2) consists of a variety of volcaniclastic rocks, mafic and intermediate flows, and felsic units, both extrusive and intrusive (i.e. domes or subvolcanic intrusions), that are intruded by mafic sheets and dykes. A large gabbroic body lies just south of the deposit, and is the source of the numerous mafic dykes that cut the ore zone (Watson, 1957). Many previous workers have noted that the stratigraphy youngs to the northwest and that rocks beneath the deposit area are dominantly felsic (the rhyolite porphyry unit in Fig. 2), whereas along strike and stratigraphically overlying the deposit intermediate volcanic and sedimentary rocks dominate with rare occurrences of felsic rocks. In addition, the stratigraphy thickens to the northeast and down-dip of the deposit, which suggests that the depositional basin may have thickened to the northeast.

Based on logging of drill core, the stratigraphy immediately beneath the ore zones is dominated by fine- to medium-grained, dark green to dark grey volcaniclastics commonly displaying graded beds of cm to m thickness. These rocks are cut at depth by rhyolite porphyry. This simple stratigraphy is complicated by: (1) stratigraphic facing directions to the east in the upper part of hole KA2 (Fig. 3), as indicated by graded bedding, which suggest that a fold closure may exist; and (2) interference patterns (Type 1) present in drill core reflect overprinting of earlier folds (F_1) by second generation (F_2) folds. Thus, it is likely that isoclinal folds are present. Further complicating interpretation of the geology are the following: (1) lateral facies changes, (2) uncertainty of whether felsic and volcanic units are flows, sills or subvolcanic plugs, and (3) presence of a variety of alteration types (carbonate, silica, sericite, epidote).

Of particular relevance to this work is the extent of a large felsic centre extending beneath the ore zones which is interpreted to be subvolcanic in origin based on the dominantly massive nature of the rock, mutual cross-cutting relationships of felsic porphyry with other felsic dyke rocks, and cross-cutting relationships with the volcaniclastic rocks observed in drill core. This unit may be similar to the subvolcanic sills and porphyries that underlie many massive sulphide deposits, as discussed by Galley (1996), and an integral part of current models for massive sulphide deposit formation (Franklin, 1993). These intrusions provided the energy for circulating hydrothermal fluids which caused leaching and alteration in an extensive zone above the subvolcanic intrusion.

Alteration Profile

In order to examine the nature of the QTC rock, cores from several drillholes were logged; representative drill-hole sections are illustrated in Figure 3. These drillhole logs together define an oblique longitudinal section. A core section of altered volcaniclastic rock from diamond-drill hole KA-2 (Fig. 4) was sampled in detail for lithogeochemistry.

In drill core one observes the generally monotonous, banded and graded, dark green-grey volcaniclastic unit as footwall rock beneath the massive sulphide zone, although near the mineralized zone the rocks are distinctly finer grained and layering is on a mm to cm scale (versus cm to m scale farther beneath the sulphide zone). A well developed fabric is present and is usually 30-40° to the core axis, but in places the fabric is parallel to the core axis, which presumably relates to folding (Fig. 3). As previously noted, interference patterns are common in drill core, particularly in QTC rock, and where intensely deformed the rock has a schistose fabric. The volcaniclastic unit becomes variably altered to a fine-grained, massive to banded, white to whitish-grey rock where dominated by quartz and carbonate, and pale buff where talc is present (Figs. 4, 5). In some sections the rock is mottled, with up to 60-80% alteration, whereas in other places the core is 100% QTC rock.

In thin section, the volcaniclastic rocks are seen to comprise variable mixtures of anhedral quartz, altered volcanic clasts with layering, carbonate, chlorite and fine-grained white mica. The QTC lithology is variable in nature with the following types present: (1) very fine-grained, massive silica-rich rock (with or without patches of coarse quartz) characterized by subgrain development and radial habit, (2) fine-grained, layered carbonate and quartz rock, and (3) carbonate rock with patches of colloform and/or radially-textured material.

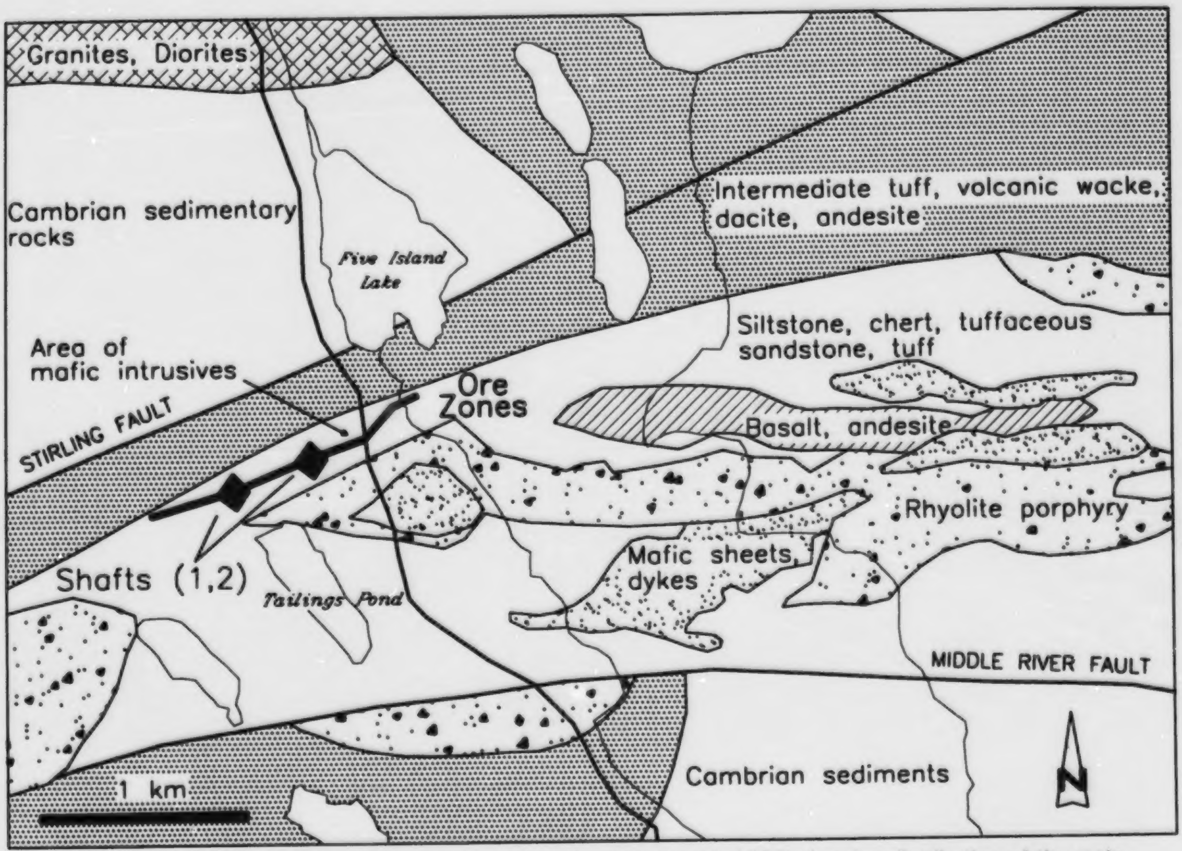

Granites, Diorites
Cambrian sedimentary rocks
Five Island Lake
Intermediate tuff, volcanic wacke, dacite, andesite
Siltstone, chert, tuffaceous sandstone, tuff
Area of mafic intrusives
STIRLING FAULT
Ore Zones
Basalt, andesite
Rhyolite porphyry
Mafic sheets, dykes
Shafts (1,2)
Tailings Pond
MIDDLE RIVER FAULT
Cambrian sediments
1 km
N

Figure 2. Geological map of the Striling area (modified after Macdonald, 1989) showing distribution of the main rock types, projection of the ore zones, location of the two shafts (#1 and #2) that accessed the deposit and the tailings pond.

The amount of deformation varies, with the latter samples obviously free of strain since delicate textures are preserved. Where sulphide is present (i.e. pyrite), the silica-carbonate material (type 2, above) is paragenetically later.

A 60 foot section of core from diamond-drill hole KA-2 illustrates well the typical nature of the QTC alteration (Fig. 4). Of particular note in this section are the following observations. (1) Dark green to black, fine-grained volcaniclastic rock is variably bleached to shades of grey and eventually the rock is completely converted to a whitish quartz-carbonate rock with no vestages of the precursor. (2) In the partially altered section, a remnant fabric is present (also see Fig. 5) which may represent primary layering observed in the unaltered rock or a layer-parallel fabric. In at least some cases the tectonic fabric and what is probably primary banding in quartz-carbonate rock (inherited) are parallel. If this layering is primary, then this is an important observation as it indicates that the alteration was a constant volume phenomenon which resulted in preservation of textures. (3) Thicknesses of the alteration zones are variable. For example, of the altered zones in Figure 4, the apparent thicknesses are ca. 8 feet, 3 feet and 16 feet. (4) The nature of quartz-carbonate veins present in both the altered and unaltered rocks suggests a relatively late-stage introduction of this material. (5) Contacts between fresh and altered rock are gradational rather than sharp.

A composite longitudinal section constructed using representative drillholes (Fig. 3), all inclined ca. 45° to the east, illustrates that 20-50% of the core is altered (note that it may reach 70% if the missing core is also altered rock) beneath the mineralized zone. Also shown in this diagram is the orientation of the fabric (seen in Fig. 5)

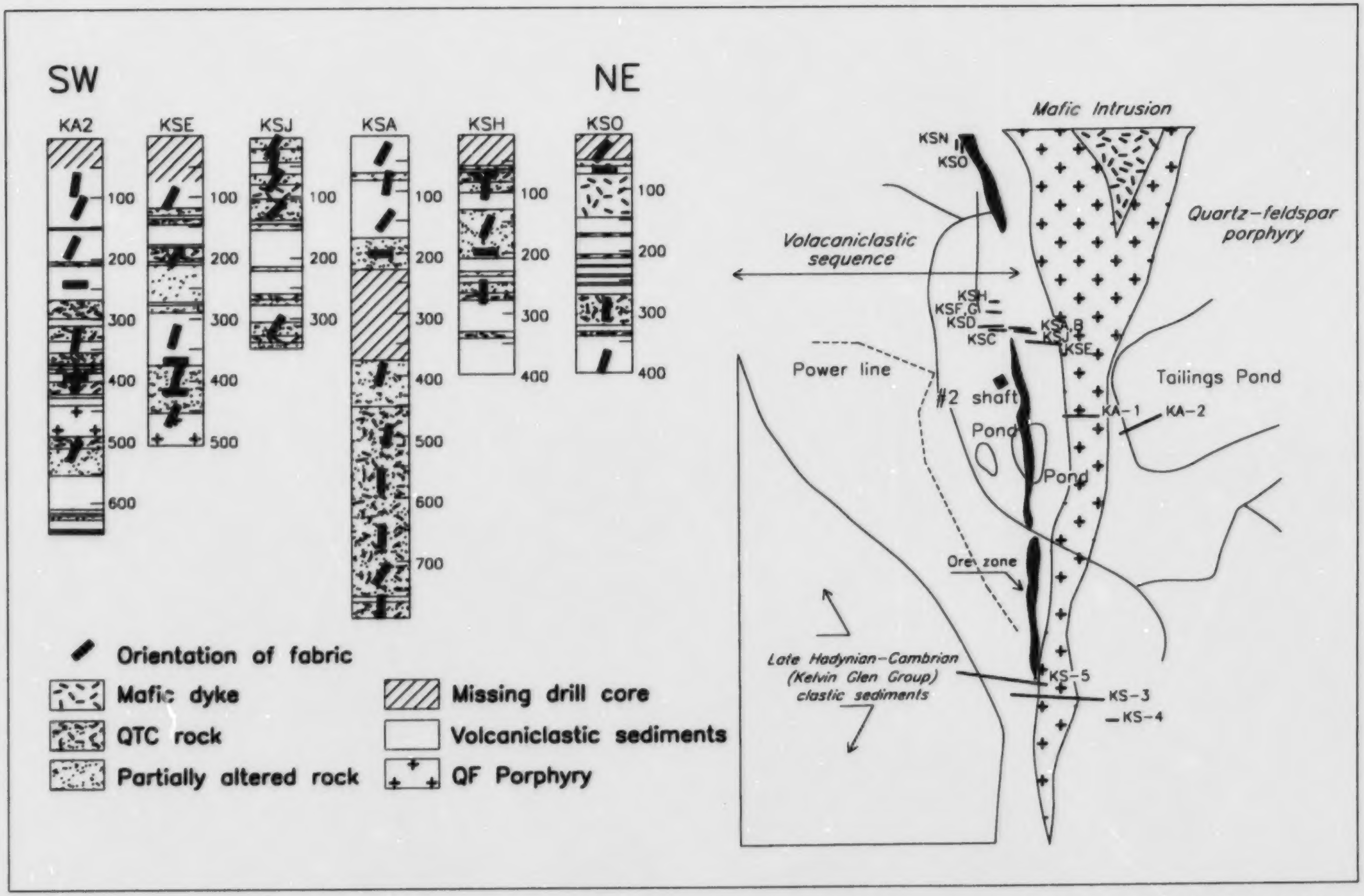

SW
NE
KA2
KSE
KSJ
KSA
KSH
KSO
100
200
300
400
500
600
700
Orientation of fabric
Mafic dyke
QTC rock
Partially altered rock
Missing drill core
Volcaniclastic sediments
QF Porphyry
Mafic Intrusion
Quartz–feldspar porphyry
Volacaniclastic sequence
KSN
KSO
KSH
KSF,G
KSD
KSC
KSA,B
KSJ
KSE
Power line
#2 shaft
Pond
Pond
Tailings Pond
KA-1
KA-2
Ore zone
Late Hadynian–Cambrian (Kelvin Glen Group) clastic sediments
KS-5
KS-3
KS-4

Figure 3. Map of the Stirling deposit area showing the outline of the quartz-feldpsar porphyry unit, the ore zone and locations of drillholes that were logged. Representative, simplified logs for several holes are shown to illustrate the extent of alteration. Note that all holes were collared at a similar elevation and were inclined ca. 45 degrees to the east.

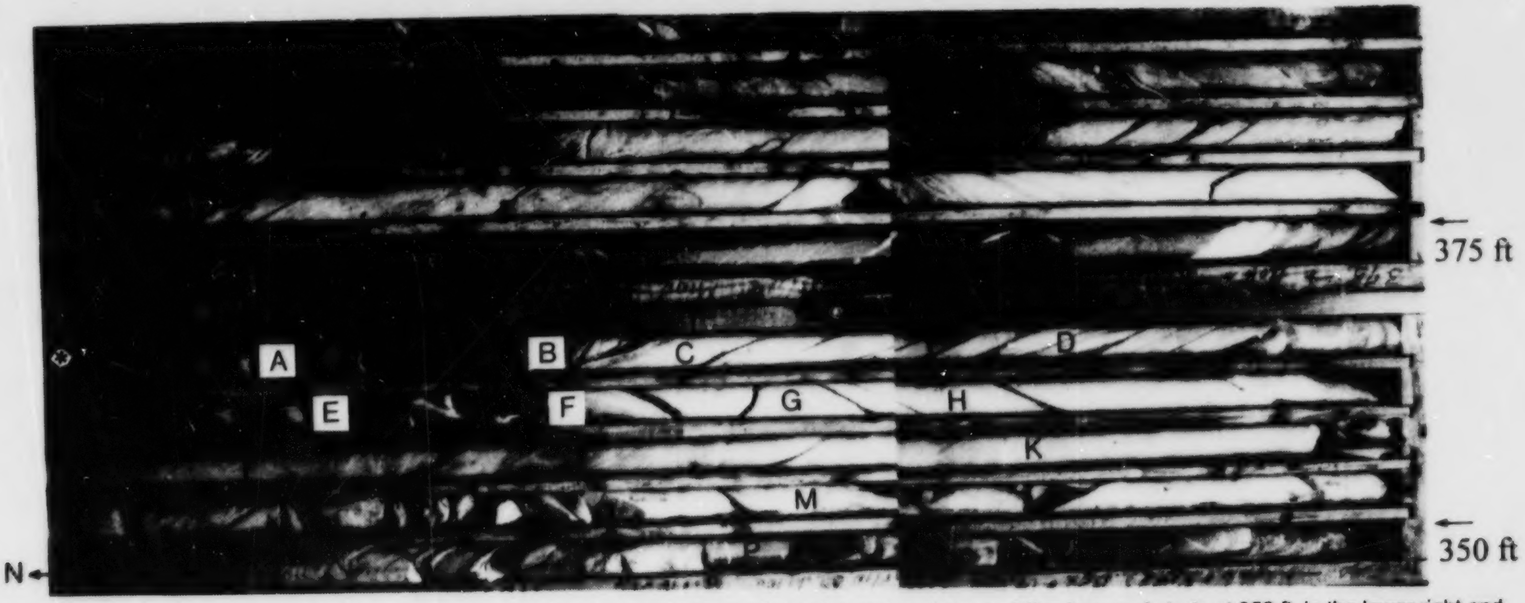


Figure 4. Photograph of diamond-drill core from hole KA-2 at the Stirling deposit. Each core length is ca. 1.5 m long and starts at 350 ft. in the lower right and goes to 400 ft. in upper left. Bleaching of the dark grey-green rock is due to variable amounts of quartz-talc-carbonate (QTC) alteration. Letters represent samples of the core that were analyzed for major and trace element chemistry (see Figs. 6, 7 and 8). Asterisk represents the point from which distances up- core were measured. Samples Q and R were taken from the next piece of core (above 350 ft.).

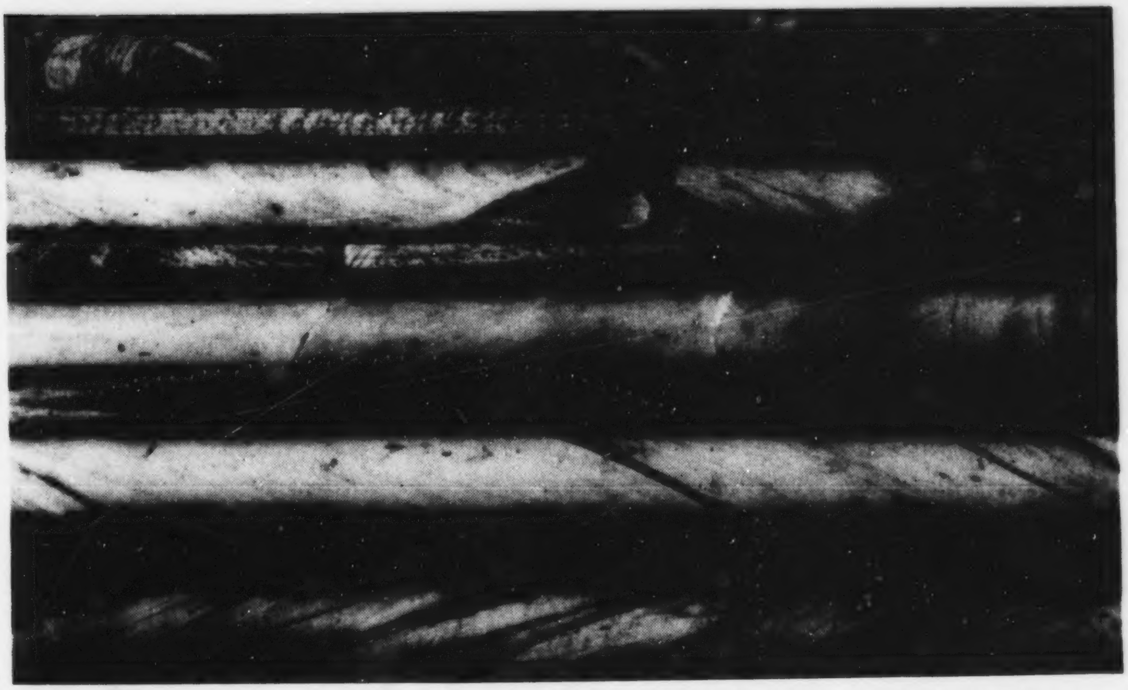


Figure 5. Photograph of diamond-drill core from hole KA-2 (box #14) at the Stirling deposit showing intense alteration of the host rock due to replacement by quartz-talc-carbonate rock. Note the well-developed fabric in the rocks and also late-stage quartz veins with alteration halos in the right end of the centre piece of core. Width of the core is ca. 3.5 cm.

relative to the core axes, which varies from oblique (30-40°) to parallel to the core axes. The orientation of this planar fabric varies down the holes and reflects folding, which appears to be considerable from the change in orientation of the fabric, and was likely isoclinal. The fact that the fabric is parallel to the core axis in hole KSA (Fig. 3) suggests that the abnormal thickness of the QTC rock in this hole may relate to drilling parallel to the fabric (layering) on the limb of a tight fold.

Lithogeochemistry

The results of major and trace element geochemical analysis (X-ray fluroescence at St. Mary's University, Halifax, Nova Scotia) and rare earth element (REE) analysis (ICP-MS, Memorial Univeristy, St. John's, Newfoundland) are presented in this section for drillhole KA-2. The major and trace element data are given in Table 1 and plotted in Figures 6 and 7, with chondrite-normalized REE plots shown in Figure 8. Additional data for volcaniclastic rocks and QTC rock are shown in Figure 9 for comparison to the alteration profile.

To ascertain the extent of geochemical enrichment and/or depletion, it is first necessary to establish which samples have retained primary geochemical signatures by using elements that are generally considered immobile. In this case, a plot of Ti/Zr versus distance up-core clearly indicates that the least altered samples, that is the darkest rocks in Figure 3 (A, B, E, P, Q and R; Fig. 6a), have retained a similar Ti/Zr ratio, whereas the altered samples have a much different signature due to the depletion of Ti (Fig. 7c). A similarly consistent pattern emerges in many other plots. (1) The transition elements (Ni, Cr, Co, V, Sc; Fig. 6b), Al_2O_3 (Fig. 7a), Fe_2O_3 (Fig. 7b) and Na_2O (Fig. 7c) behave similarly and follow the pattern established by Ti/Zr with depletion in the altered samples. The consistent trend for Al_2O_3/Fe_2O_3 (Fig. 7d) attests to the similar behaviour of these elements. (2) Absolute values of Zr (also, Y and the HREE) increase in the altered samples, whereas Nb shows the depletion trend similar to Ti (Fig. 6c). (3) Although Na_2O parallels the trend for Ti/Zr, K_2O departs from this and shows variable enrichment in the altered samples (Fig. 7c). (4) Calcium (CaO) shows

Table 1. Geochemistry for alteration profile in DDH KA2, Stirling deposit, southeast Cape Breton Island.

Sample No.	STB-98-A	STB-98-B	STB-98-C	STB-98-D	STB-98-E	STB-98-F	STB-98-G	STB-98-H	STB-98-I	STB-98-J	STB-98-K	STB-98-M	STB-98-N	STB-98-O	STB-98-P	STB-98-Q	STB-98-R
distance (cm)*	2	5	8	14	25	28	31	34	45	50	57	76	85	90	97	102	115
SiO_2	44.97	45.82	59.9	68.61	53.55	66.2	30.71	35.96	50.62	60.91	37.98	40.79	36.35	56.86	50.81	43.94	51.53
TiO_2	0.744	0.764	0.139	0.137	0.82	0.184	0.103	0.103	0.146	0.122	0.113	0.107	0.096	0.127	0.759	0.831	0.798
Al_2O_3	14.58	14.32	7.38	7.32	14.7	10.25	5.23	5.41	7.27	7.21	6.15	5.5	5.29	6.93	13.78	15.48	14.38
Fe_2O_3	9.43	9.16	2.81	2.95	9.22	5.69	4.13	3.62	3.81	5.61	3.74	3.45	3.36	3.58	8.47	10.34	10.06
MnO	0.159	0.205	0.127	0.091	0.095	0.081	0.29	0.199	0.167	0.096	0.222	0.187	0.177	0.132	0.12	0.144	0.083
MgO	6.92	6.59	4.74	3.77	7.13	5.23	10.89	10.86	7.86	7.11	9.94	9.92	10.82	6.3	5.61	7.11	6.34
CaO	9.57	7.5	9.15	5.75	3.97	3.76	19.51	17.04	11.11	6.69	15.69	15.3	16.76	9.49	7.11	7.92	5.76
Na_2O	2.83	3.06	0.16	0.34	0.76	0.64	0.41	0.2	0.35	0.26	0.55	0.66	0.32	0.09	2.58	2.47	2.13
K_2O	0.62	0.79	2.15	1.74	1.73	1.5	1.31	1.53	1.81	1.06	1.52	1.32	1.45	1.88	1.07	1.14	1.02
P_2O_5	0.068	0.076	0.018	0.019	0.087	0.024	0.017	0.016	0.017	0.02	0.018	0.018	0.017	0.021	0.096	0.087	0.083
L.O.I.	11.45	11.7	13.85	9.26	8.42	7.2	27.73	26.42	17.95	11.96	24.68	23.9	26.05	15.29	11	11.88	8.71
Total	101.34	99.98	100.42	99.98	100.48	100.75	100.33	101.35	101.11	101.04	100.60	101.15	100.69	100.7	101.40	101.34	100.89
CO_2	7.34	8.66	12.37	7.6	4.4	4.62	25.4	22.57	14.64	10.2	22.57	22.17	22.53	12.77	7.82	8	5.21
H_2O																	
Sc	27	9	0	23	53	16	0	0	0	0	0	0	0	0	8	24	43
V	236	239	0	10	228	7	3	10	5	9	2	0	0	0	199	246	234
Cr	574	500	0	0	479	0	0	0	0	0	0	0	0	0	429	454	467
Co	48	36	0	1	40	13	1	3	3	4	1	0	1	2	32	43	45
Zr	40	45	231	237	48	301	159	165	233	208	184	176	170	149	43	41	46
Ba	227	82	315	157	246	105	227	221	361	266	245	146	132	369	68	66	75
La	6	0	8	15	0	23	11	11	31	16	7	13	16	27	2	0	0
Ce	0	0	20	66	0	0	42	0	18	0	34	36	24	0	22	0	26
Nd	7	14	17	31	16	27	19	14	24	20	17	18	7	17	7	0	0
Ni	69	60	15	42	59	69	10	3	13	20	1	10	24	33	52	54	56
Cu	41	40	8	7	88	7	32	11	9	15	13	9	18	10	64	66	88
Zn	99	188	74	114	528	353	89	217	181	424	115	115	111	127	233	216	522
Ga	12	12	17	13	16	19	10	7	17	14	9	11	9	10	12	15	15
Rb	36	40	78	75	56	63	51	59	68	55	59	57	58	71	46	42	42
Sr	112	96	81	51	42	42	148	143	94	63	131	126	137	86	87	78	68
Y	17	16	44	46	18	74	40	34	56	76	44	40	35	27	16	19	19
Nb	13	11	0	0	10	3	7	4	0	0	3	2	2	0	9	15	13
Sn	0	2	2	4	0	4	1	2	0	1	2	3	2	1	1	1	1
Pb	25	6	20	19	20	39	44	79	21	22	14	16	17	16	14	8	17
Th	1	1	1	1	2	5	4	3	2	2	1	3	2	3	1	0	0
U	0	1	0	0	0	2	0	0	0	1	0	0	0	1	2	0	0

*distance in cm from the spot marked * on core. Fig. 4. 0=below detection limit

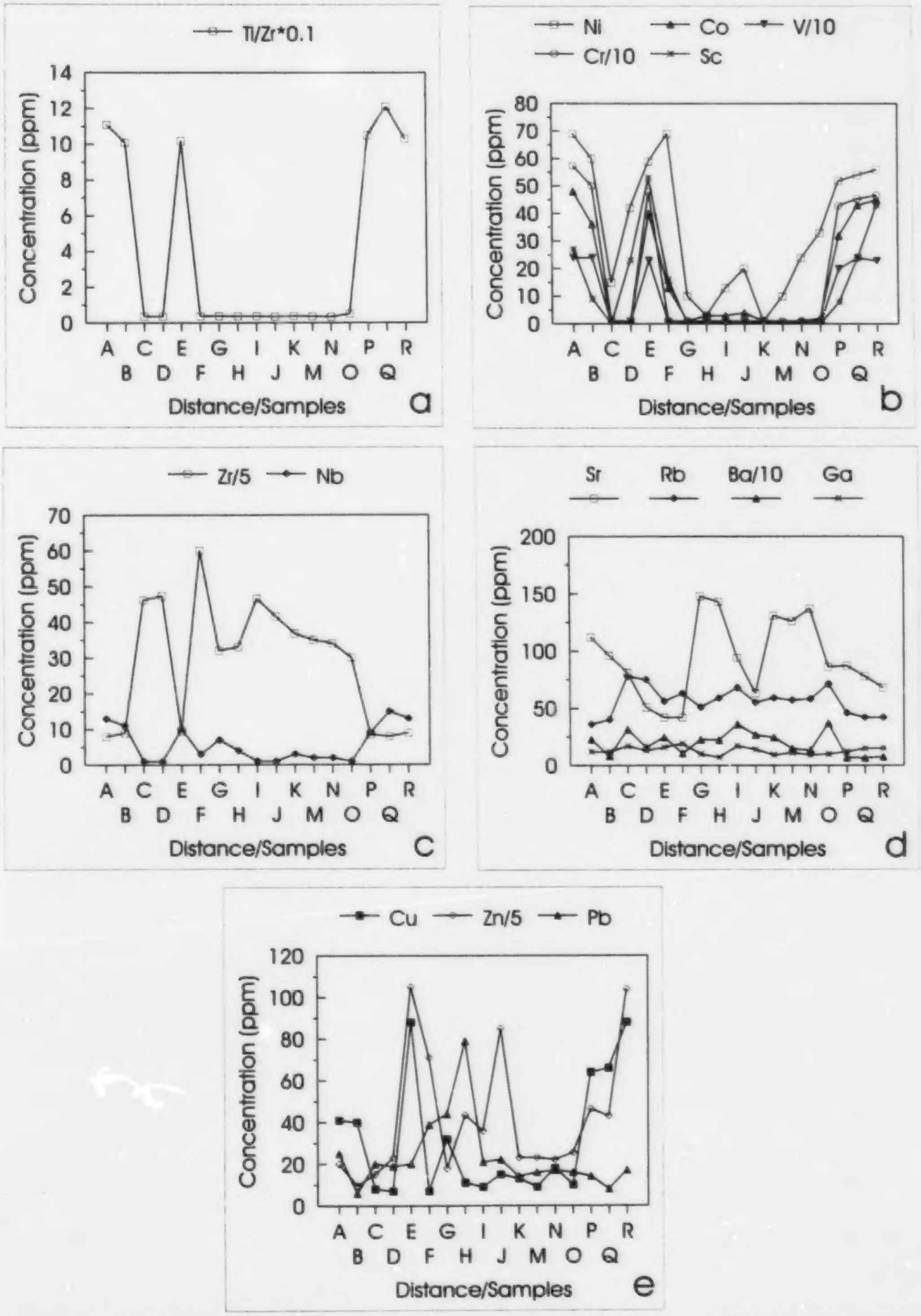


Figure 6. Plots of minor and trace element whole-rock geochemistry for alteration profile at Stirling deposit. Samples correlate to those shown in Figure 4. See text for discussion. Note the elevated Ti/Zr ratios for the least altered host rock samples compared to the alteration profile.

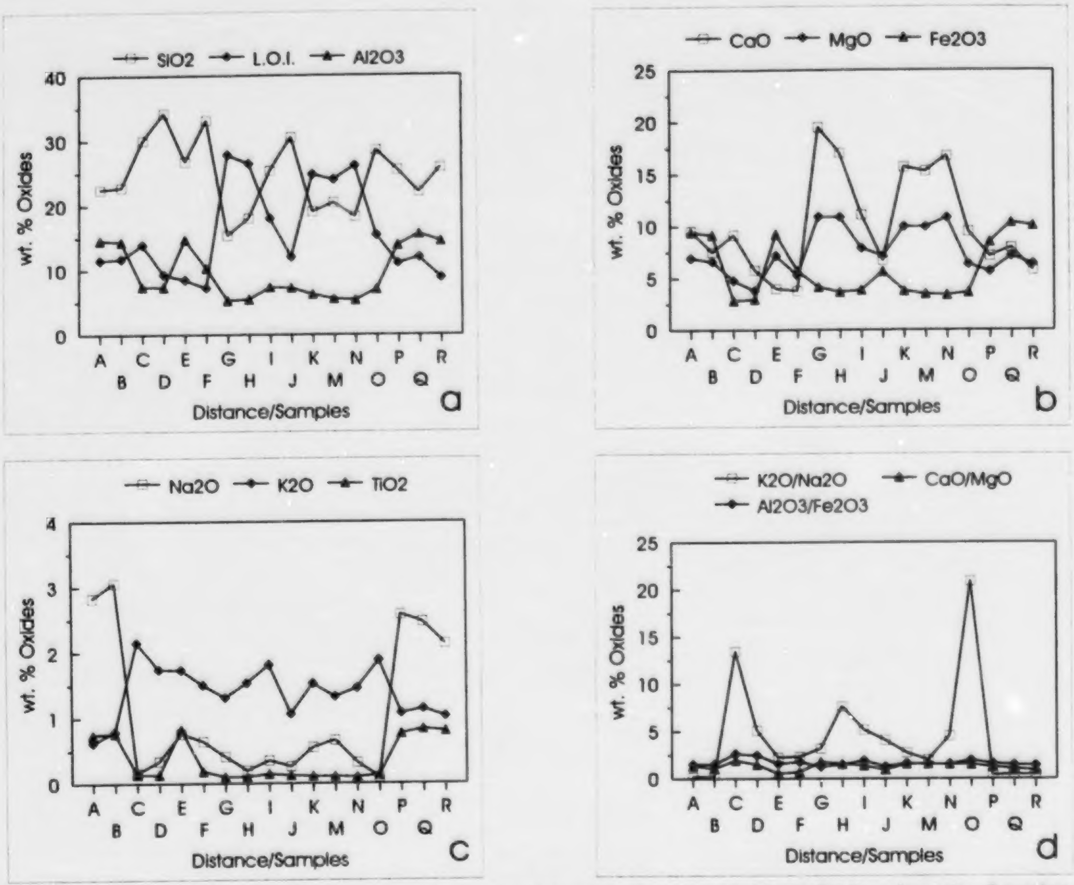


Figure 7. Plots of major element whole-rock geochemistry for alteration profile at Stirling deposit. Samples correlate to locations shown in Figure 4. See text for discussion. Note the elevated Na_2O contents of the least altered host rock samples compared to the alteration profile.

variable enrichment (Fig. 7b) and the CaO/MgO trend indicates that these elements are not completely coupled (i.e. in a phase other than dolomite). (5) Base metals (Cu, Pb, Zn) show an erratic profile with general depletion relative to the host rocks. Finally (6), the trend for LOI parallels that of CaO and reflects the presence of carbonate. Collectively, the geochemical profile shows variable mobility of elements that relate to the formation of carbonate, quartz and talc for the major elements. For the minor and trace elements (e.g. Y, Zr, REE), other phases must be present that have not yet been identified.

Chondrite-normalized plots of REE for an unaltered wallrock sample (A) shows a generally flat trend at 6-8 times chondrite, which contrasts with the 30-50 times chondrite normalized patterns for altered samples (C, I, M) (Fig. 8). In addition, the altered samples are all characterized by negative Eu anomalies (Eu/Eu* <1), a feature notably absent in the fresh sample, and all have the same flat, unfractionated pattern as the unaltered sample (A). In order to see if this apparent enrichment of the REE and development of the negative Eu anomaly is characteristic of the QTC rock, several other samples of volcaniclastic and QTC rock were analyzed and these results are shown in Figure 9.

In Figure 9a the unaltered volcaniclastics show generally flat, unfractionated to slightly fractionated chondrite-normalized patterns with slight LREE enrichment and only slight negative Eu anomalies. The two samples (STB-98-1021, 1043) with the highest REE abundances were also proximal to the ore zone, an interesting point that is currently being investigated and which may have implications for identification of mineralizing processes. In Figure 9b the chondrite-normalized REE plots for QTC rocks are shown,

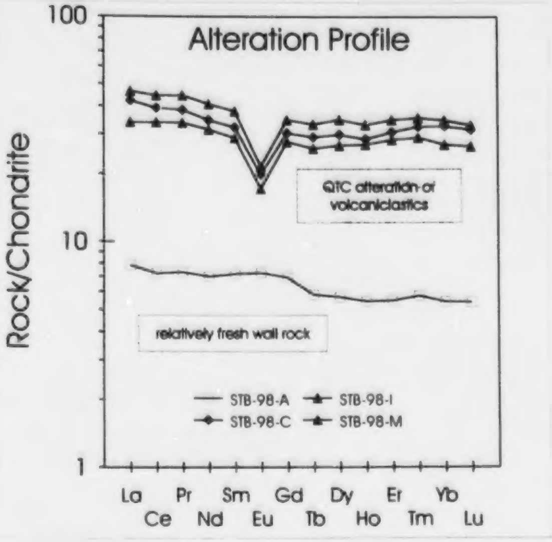


Figure 8. Chondrite-normalized rare earth element plot for relatively fresh host rock (wallrock) and quartz-talc-carbonate altered rocks from diamond-drill hole KA-2.

including samples (STB-98-C, I, M) from the alteration profile for comparison. Collectively the data show a range from ca. 1 to ca. 60 times chondrite abundances, and only samples in excess of 10 times chondrite have negative Eu anomalies. The simple scenario apparent for the alteration profile, with REE enrichment accompanying alteration, may be an artifact of limited sampling, or enrichment of the REE and development of a negative Eu anomaly may relate to hydrothermal activity as per the discussion about samples STB-98-1021 and -1043. Clearly, further investigation of this data set is warranted and any conclusions are premature at this stage.

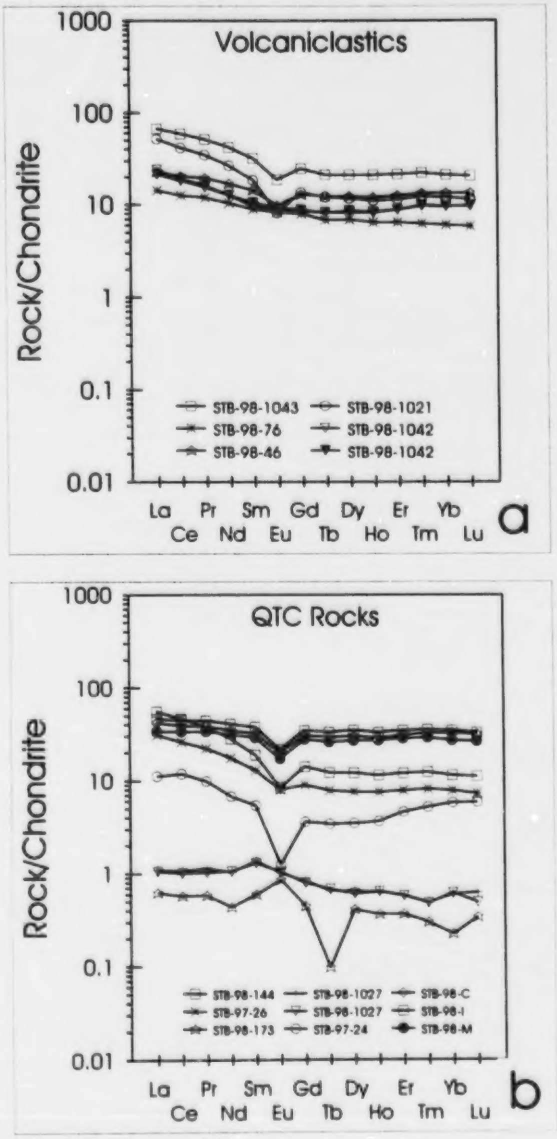


Figure 9. Chondrite-normalized rare earth element plots for relatively fresh volcaniclastics and QTC rocks from the Stirling deposit. Note that there is a large range in the data for the QTC rocks compared to the fresh volcaniclastics.

Discussion

Alteration Origin for QTC Rock

The presence of intense bleaching of volcaniclastic host rocks beneath the ore zone at the Stirling massive sulphide deposit has been documented. The presence of quartz-carbonate-talc (QCT) rock forming extensive alteration zones which post-date sulphide mineralization (Kontak, 1998) is a marked change from previous interpretations that QTC rock represents syngenetic accumulations of this material on the ocean floor. However, at one locality there is compelling evidence for syngenetic accumulation of QTC rock at or near the ocean floor (Kontak, 1999). Based on logging of drill core, alteration is estimated to extend the length of the area shown in Figure 3 and it may in fact continue to the east and west. The apparent thickness is up to 100 m, but this is complicated by structure, as noted above with reference to drillhole KSA (Fig. 3). This same alteration also extends into the porphyry unit at depth, based on observations and subsequent geochemistry (unpublished data of Kontak). Thus, the amount of material affected by fluid:rock interaction has been considerable.

Lithogeochemistry of an alteration profile indicates extreme enrichment and depletion of many elements, including some that are generally considered to be immobile during alteration (e.g. Ti, Zr, REE). The apparent lack of any conserved elements throughout the alteration profile precludes determination of gains and losses of material (e.g. Grant, 1986). However, the presence of well-developed, primary layering throughout fresh and altered sections of drill core suggests that alteration was a constant volume process. Thus the relative gains and losses are real and not related to changes in rock volume, although some may be attributable to a change in rock mass. The deposition of carbonate-rich material occurred in alkaline conditions, which contrast markedly with the acid-dominated systems associated with most alteration environments and massive sulphide deposits (Franklin, 1993). It is thus pertinent to note that mobility of many of the 'immobile' elements (e.g. Ti, Nb, Zr, REE) has been documented in alkaline environments.

Among the major and minor elements the most enriched are CaO, MgO, SiO_2 and K_2O, whereas the most depleted are Na_2O, Al_2O_3 and TiO_2. The mineralogy of the alteration zone, consisting of carbonate, quartz and talc, reflects this chemical signature except for K_2O, which suggests the presence of a white mica phase. Depletion of Al_2O_3 reflects the breakdown of feldspar and chlorite in the host rock. The relative enrichment of all the REE without any apparent fractionation indicates inheritance of this pattern from the host rocks and also requires very large amounts of fluid (high fluid:rock ratios). The presence of a negative Eu anomaly in the altered rocks is a reflection of the redox state of the fluid and hence dominance of Eu^{2+} over Eu^{3+}. The absence of a Ce anomaly, characteristic of marine sediments and ocean water, precludes involvement of unmodified seawater in generation of the QTC rock, which is also consistent with the negative Eu anomalies. Instead, formation of the QTC rock involved passage of a fluid that exchanged and equilibrated with rocks at depth, although it may originally have been ocean water.

The combination of visual observations, petrographic examination of thin sections, and lithogeochemistry of the QTC rock from drill core is interpreted to indicate an origin by variable replacement of the volcaniclastic host rock. Further work is focusing on the nature and origin of the QTC rock in order to better define its origin and determine what role it played role in the formation of the Stirling massive sulphide deposit.

Analogies with Other Massive Sulphide Deposits

Analogies with other districts indicate that both low- and high-temperature hydrothermal systems may exist in close proximity, as mentioned in the introduction with reference to the Errington and Vermilion Zn-Cu-Pb massive sulphide deposits of the Sudbury district (Rousell *et al.*, 1997). Another analogy to the QTC rock at Stirling is the presence of voluminous amounts of secondary chert associated with the giant ore deposits of the Iberian pyrite belt. Recently, Leistel *et al.* (1998) have described these rocks as forming at or beneath the sea floor through chemical precipitation and/or alteration of the host rock and at temperatures well below formation of the massive sulphide rocks. Although a genetic relationship with massive sulphide mineralization was not proposed, the authors did emphasize the importance of the chert as a paleodynamic indicator (i.e., if the chert is present then so might there be massive sulphide). A similar approach is tentatively proposed for Stirling, with the QTC rock an indicator of the appropriate paleotectonic setting for massive sulphide mineralilzation.

In summary, an alteration origin is proposed for quartz-talc-carbonate rock at the Stirling deposit, although this does not exclude the potential for a small amount of exhalative material cogenetic with formation of the sub-sea floor alteration zones. Modern analogues such as calcareous sinters or travertine suggest a low temperature origin for the QTC rock, which contrasts with higher temperatures generally inferred for massive sulphide formation. Thus, two competing hydrological systems are considered to have coexisted spatially and temporally and may have been related to the presence of an underlying felsic magma represented today by a large body of quartz-feldspar porphyry. Similarities of the setting of the Stirling district to other massive sulphide camps with variations on the quartz-carbonate-talc alteration style (e.g. Sudbury area, Sweden, Iberia) suggest a high potential for the Stirling area.

References

Alcock, F. J. 1930: Zinc and lead deposits of Canada; Geological Survey of Canada, Economic Geology Series No. 8, p. 41-46.

Barr, S. M., White, C. E. and Macdonald, A. S. 1996: Stratigraphy, tectonic setting, and geological history of the Late Precambrian volcanic-sedimentary-plutonic belts in southeastern Cape Breton Island, Nova Scotia; Geological Survey of Canada, Bulletin 468.

Franklin, J. F. 1993: Volcanic-associated massive sulphide deposits; *in* Mineral Deposit Modeling, eds. R. V. Kirkham, W. D. Sinclair, R. I. Thorpe and J. M. Duke; Geological Association of Canada, Special Paper 40, p. 315-334.

Franklin, J. F., Sangster, D. F. and Lydon, J., 1981: Volcanic-associated massive sulphide deposits; Economic Geology, 75th Anniversary Volume, p. 485-627.

Galley, A. G. 1996: Geochemical characteristics of subvolcanic intrusions associated with Precambrian massive sulphide districts; *in* Trace Element Geochemistry of Volcanic Rocks, Applications for Massive Sulphide Exploration, ed. D. Wyman; Geological Association of Canada, Short Course Notes, v. 12, p. 239-278.

Grant, J. A. 1986: The isochon diagram - a simple solution to Gresens' equation for metasomatic alteration; Economic Geology, v. 81, p. 1976-1982.

Kontak, D. J. 1998: Preliminary results of geological and geochemical studies at the Stirling deposit with emphasis on quartz-talc-carbonate (QTC) rock associated with massive sulphide ore; *in* Minerals and Energy Branch Report of Activities 1997, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Report 98-1, p. 49-70.

Kontak, D. J. 1999: Superimposition of quartz-carbonate-talc sinter deposits with massive sulphide mineralization in a 680 Ma hydrothermal sea floor setting at Stirling, southeast Cape Breton Island, Nova Scotia; *in* Program with Abstracts, Atlantic Geoscience Society Annual Meeting, Amherst, Nova Scotia, February 1999.

Leistel, J. M., Marcoux, E. and Deschamps, Y. 1998: Chert in the Iberian pyrite belt; Mineralium Deposita, v. 33, p. 59-81.

Macdonald, A. S. 1989: Metallogenic studies, southeastern Cape Breton Island; Nova Scotia Department of Mines and Energy, Paper 89-1, 99 p.

Macdonald, A. S, and Barr, S. M. 1993: Geological setting and depositional environment of the Stirling Group of southeastern Cape Breton Island, Nova Scotia; Atlantic Geology, v. 29, p. 137-147.

Miller, C. K. 1979: The geological setting and environment of base metal deposition at the Mindamar mine, Stirling, Richmond County, Nova Scotia; unpublished M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia.

Poole, W. H. 1974: Stratigraphic framework of volcanogenic massive sulphide deposits, Northern Appalachian Orogen; Geological Survey of Canada, Paper 74-1, Part B, p. 11-17.

Rousell, D. H., Gibson, H. L. and Jonasson, I. R. 1997: The tectonic, magmatic and mineralization history of the Sudbury structure; Exploration and Mining Geology, v. 6, p. 1-22.

Watson, K. D. 1954: Paragenesis of the zinc-lead-copper deposits at the Mindamar mine, Nova Scotia; Economic Geology, v. 49, p. 389-412.

Waton, K. D. 1957: Mindimar mine, Appalachian Region; *in* Structural Geology of Canadian Ore Deposits, v. 2; CIM Special Volume, 6th Commonwealth Mining and Metallurgical Congress, Canada, p. 495-502.

Weeks, L. J. 1924: Geology and ore deposits of Stirling area, Richmond County, Nova Scotia; Geological Survey of Canada, Summary Report, Part C, p. 199-217.

Weeks, L. J. 1954: Southeast Cape Breton Island, Nova Scotia; Geological Survey of Canada, Memoir 277, 112 p.

Geoscience Editing and Publishing

D. R. MacDonald, B. L. MacDonald, K. A. Mills, J. S. Saunders and A. Miller

The role of the geoscience editing and publishing group in the Geoscience Information Services Section can be roughly divided into two parts. The first part involves editing a manuscript (report, article or map) to the author's satisfaction while at the same time applying the Branch standards for style and content. Editor Doug MacDonald and contract editor Kathy Mills carry out this work for the Minerals and Energy Branch. The second part involves producing a published document. The editors work with word processing operators Barb MacDonald, Susan Saunders and Angela Miller to produce our branch publications.

Editing

In the Minerals and Energy Branch, all scientific publications must be reviewed by at least one scientist who has not contributed to the research being presented. This process is called peer review and finding a suitable reviewer is usually the editor's first task after receiving a manuscript. The editor assigns the manuscript to a reviewer who is experienced in the field of study being presented by the author. The editor supplies the reviewer with detailed guidelines to direct the review toward the most critical scientific aspects of the manuscript:

1. significance of the content,
2. soundness of the content,
3. completeness of the content, and
4. presentation.

The reviewer's comments are then given to the author so that the manuscript can be revised in an effort to improve its scientific content. Open File Reports and Open File Maps are publications used to release information as soon as possible, and can be approved for release after peer review and minimal editing.

Resubmission of the manuscript after peer review initiates the next step in the editorial process, often called 'substantive' editing. This step may require re-writing parts of the document, re-organizing sections, and generally suggesting ways that the author can improve the presentation of their research for its intended readers. Since the subject matter is geoscience, the editors are geologists. Although the editors cannot be experienced in the particular field of research for each manuscript they understand the concepts, terminology, and scientific methods employed. The relationship between author and editor is most important during this phase of substantive editing.

Another aspect of the editorial process is often referred to as 'copy' editing. This function requires careful attention to every detail in a document in order to meet the Branch publication standards. For the Minerals and Energy Branch, these standards reflect those used by the Geological Survey of Canada. Some standards, such as consistent capitalization, spelling and punctuation, are easily applied. Others may require much more time and effort, such as accurate citation and listing of references, and making sure that tables, maps and drawings meet the appropriate specifications.

Publishing

The final appearance of our publications is largely determined by the publication team, which includes an editor and a word-processing operator. In the modern age of computer-based publication, the job title 'word processing operator' is an anachronism. This function consists of preparing camera-ready (or Internet-ready) manuscripts for publication, and involves words, figures, tables and other design elements that are electronically composed using a variety of publishing applications, such as WordPerfect® and PageMaker®. Manuscripts travel back and forth between the editor and the word processing operator many times before they are ready to be published, either on paper or on-line.

Staff of the geoscience editing and publishing group work toward the goal of consistent high-quality, timely, and cost-effective reporting on activities carried out by the Minerals and Energy Branch. All geoscientists in the Branch are required to publish accounts of their work. These accounts may be published as scientific reports, memoirs or maps, or they may best be communicated in less technical publications such as information circulars or newsletters. The Branch newsletter *Nova Scotia Minerals Update* is produced quarterly and distributed to approximately 1600 subscribers around the world. The newsletter and many of our other, shorter publications are also converted to HyperText Markup Language (HTML) and are available on-line as part of the Branch web site. These activities ensure that current geoscience information on Nova Scotia is readily available to enhance public awareness and to promote the mineral resources of the province.

The following publications were released in 1998:

Annual Report

Annual Report for the Fiscal Year ending March 31, 1997, by Nova Scotia Department of Natural Resources 1998, 92 pages.

Contribution Series

CS ME 1998-1 Gold and Base Metals Highlight Exploration in 1997, by Paul D. McCulloch; *presented at* 1998 Prospectors and Developers Association Meeting, March 1998, p. 1-6.

CS ME 1998-2 Deglaciation of Nova Scotia: Stratigraphy and Chronology of Lake Sediment Cores and Buried Organic Sections, by Rudolph R. Stea and Robert J. Mott; *in* Géographie physique et Quaternaire, vol. 52, no. 1, 1998, p. 3-21.

CS ME 1998-3 Earth Science and Engineering: Urban Development in the Metropolitan Halifax Region, by C. F. Michael Lewis, Brian B. Taylor, Rudolph R. Stea, Gordon B. J. Fader, Richard J. Horne, S. Greg MacNeil, Joe G. Moore; *in* Urban Geology of Canadian Cities, edited by P. F. Karrow and O. L. White, Geological Society of Canada, Special Paper 42, 1998, p. 409-444, 5 coloured maps.

CS ME 1998-4 A Review of the Mesothermal Gold Deposits of the Meguma Group, Nova Scotia, Canada, by R. J. Ryan and P. K. Smith; *in* Ore Geology Reviews, 13 (1998), p. 153-183.

CS ME 1998-5 Modeling Fluid-Rock Interaction During Greisenization at the East Kemptville Tin Deposit: Implications for Mineralization, by Werner E. Halter, Anthony E. Williams-Jones and Daniel J. Kontak; *in* Chemical Geology, 150 (1998), p. 1-17.

CS ME 1998-6 A Study of Fluid Inclusions in Sulfide and Nonsulfide Mineral Phases from a Carbonate-Hosted Zn-Pb Deposit, Gays River, Nova Scotia, Canada, by Daniel J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 793-817.

CS ME 1998-7 Aqueous and Liquid Petroleum Inclusion in Barite from the Walton Deposit, Nova Scotia, Canada: A Carbonate-Hosted Ba-Pb-Zn-Cu-Ag Deposit, by Daniel J. Kontak and D. F. Sangster; *in* Economic Geology, vol. 93, 1998, p. 845-868.

CS ME 1998-8 $\delta^{13}C$-$\delta^{18}O$-$^{87}Sr/^{86}Sr$ Covariations in Ore-Stage Calcites at and around the Gays River Zn-Pb Deposit (Nova Scotia, Canada) - Evidence for Fluid Mixing, by Martine M. Savard and Daniel J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 818-833.

CS ME 1998-9 Fluid Composition and Thermal Regime during Zn-Pb Mineralization in the Lower Windsor Group, Nova Scotia, Canada, by Guoxiang Chi, Daniel J. Kontak and Anthony E. Williams-Jones; *in* Economic Geology, vol. 93, 1998, p. 883-895.

CS ME 1998-10 Sub-Basin-Specific Pb and Sr Sources in Zn-Pb Deposits of the Lower Windsor Group, Nova Scotia, Canada, by D. F. Sangster, M. M. Savard and D. J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 911-919.

CS ME 1998-11 A Genetic Model for Mineralization of Lower Windsor (Viséan) Carbonate Rocks of Nova Scotia, Canada, by D. F. Sangster, M. M. Savard and D. J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 932-952.

Illustrations

Illustration ME 1998-1 The Fossil Cliffs of Joggins: Towards World Heritage Site Designation, by J. H. Calder, 1998, 16" x 21" colour poster.

Illustration ME 1998-2 Brule Fossil Site Project: Preserving and Developing a World Class Fossil Discovery in Nova Scotia, by J. H. Calder, and H. E. K. van Allen, 1998, 16" x 21" colour poster.

Illustration ME 1998-3 Sydney Mines: Fossil Interpretation Project, by J. H. Calder, 1998, 16" x 21" colour poster.

Information Circulars

IC ME 57 Properties Available for Option in Nova Scotia, January 1998, a joint project between the Nova Scotia Department of Natural Resources, Minerals and Energy Branch, the Chamber of Mineral Resources of Nova Scotia and the Mining Society of Nova Scotia, 1998, 70 pages.

IC ME 58 A Guide to Mineral Exploration Legislation in Nova Scotia, 1998, 8 pages.

Open File Illustrations

OFI ME 1998-1 Industrial Minerals, Natural Gas Production in 1999 - New Opportunities, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster.

OFI ME 1998-2 What's New, Exploration and Development Highlights, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster.

Open File Maps

OFM ME 1998-1 Preliminary geological map of Guysborough, Richmond and Antigonish Counties (parts of NTS sheets 11E/08, 11F/05, 11F/06, 11F/10, 11F/11, 11F/12 and 11F/15), Nova Scotia, by C. E. White and S. M. Barr. 1 coloured map, scale 1:100 000.

OFM ME 1998-2 Surficial Geology of the Bridgetown area (NTS 21A/14), Annapolis County, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998. 1 coloured map, scale 1:50 000.

OFM ME 1998-3 Surficial Geology of the Shubenacadie area (NTS 11E/03), Colchester, Halifax and Hants Counties. Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998. 1 coloured map, scale 1:50 000.

OFM ME 1998-4 Geological Map of Halifax Airport (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by D. E. Baker, R. J. Horne and M. Feetham. 1 coloured map, scale 1:10 000.

OFM ME 1998-5 Geological Map of Soldier Lake (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by M. Feetham, R. J. Horne, D. E. Baker and L. J. Ham, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-6 Geological Map of Fall River (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and D. E. Baker, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-7 Geological Map of Lucasville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and L. A. MacDonald, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-8 Geological Map of Middle Sackville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, L. A. MacDonald and D. E. Baker, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-9 Geological Map of Waverley (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, D. E. Baker and L. J. Ham, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-10 Geological Map of Newport Corner (part of NTS sheet 11D/13), Hants County, Nova Scotia, by R. J. Horne, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-11 Geological Map of Woodville (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-12 Geological Map of Bill Meadow Mountain (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-13 Geological Map of Renfrew (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998. 1 coloured map, scale 1:10 000.

OFM ME 1998-14 Geological Map of the McAdams Lake area, Cape Breton County (parts of NTS sheets 11F/15, 11F/16, 11K/01 and 11K/02), Nova Scotia, by C. E. White and S. M. Barr, 1998. 1 coloured map, scale 1:20 000.

OFM ME 1998-15 Map of Active Mines of Nova Scotia, by Ian McLellan, June 1998, 1 map, scale 1:1 000 000.

Open File Reports

OFR ME 1998-1 Minerals and Energy Branch, Nova Scotia Department of Natural Resources, Province of Nova Scotia: An Organization Review, by C. G. Miller, Industry Government Relations Group, 1998, 60 pages.

OFR ME 1998-2 NTS Location Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports, Contribution Series, Digital Geoscience Data Products, Open Files and Publications, 1996 and 1997, by Paul D. McCulloch, Sandra Marshall, Norman A. Lyttle and J. Susan Saunders, 1998, 51 pages.

OFR ME 1998-3 Author Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports, Contribution Series, Digital Geoscience Data Products, Open Files and Publications, 1996 and 1997, by Paul D. McCulloch, Sandra Marshall, Norman A. Lyttle and J. Susan Saunders, 1998, 72 pages.

OFR ME 1998-5 Classic Carboniferous Sections of the Minas and Cumberland Basins in Nova Scotia: with Special Reference to Organic Deposits, by J. H. Calder, R. C. Boehner, D. E. Brown, M. R. Gibling, P. K. Mukhopadhyay, R. J. Ryan and D. M. Skilliter; The Society for Organic Petrology, Annual Meeting Field Trip Guide Book, 29-30 July, 1998, 86 pages.

Reports

Report ME 1998-1 Minerals and Energy Branch Report of Activities 1997, edited by D. R. MacDonald and K. A. Mills, 212 pages.

Report ME 1998-2 Mining Matters for Nova Scotia '98: Opportunities for Economic Development, edited by D. R. MacDonald, 1998, 37 pages.

Mining Matters for Nova Scotia '98: forging new partnerships

M. A. MacDonald

Introduction

The Nova Scotia Department of Natural Resources (DNR), and the same group under its former names, has been hosting an annual conference in the Fall of each year since 1977. In the early days the conference, which we called an 'Open House', was held at the Technical University of Nova Scotia. In later years the name was changed to 'Annual Review of Activities' and the event was held in several Halifax venues, including the Lord Nelson Hotel, The Sheraton Hotel, and more recently, the World Trade and Convention Centre.

The conference has traditionally focused on the results of geoscience research by DNR and other research agencies. The conference has also provided a forum for the geoscience community of Nova Scotia to meet and discuss issues of mutual concern. In the early years of the conference, technical presentations and displays were delivered entirely by departmental staff. Gradually, the conference expanded to include representatives from local universities and the Geological Survey of Canada in Ottawa and Dartmouth. In the late 1980s, the Chamber of Mineral Resources of Nova Scotia (CMRNS) was invited to participate in the conference, and hosted technical sessions and workshops. In 1996, the Mining Society of Nova Scotia (MSNS) began holding its annual Fall meeting in conjunction with the DNR 'Review of Activities'.

Redefining the Annual Conference

In early 1998, the author was asked to review DNR's annual conference to determine if the event was attaining its goals and objectives. After consultation with departmental staff, representatives from the mineral industry, and external geoscience agencies, I recommended that fundamental changes be made to the conference. The new focus would highlight opportunities for mineral-related economic development with an emphasis on developing new linkages and partnerships with non-traditional client groups. To reflect this fundamental change in focus, the name of the conference was changed from 'Review of Activities' to 'Mining Matters for Nova Scotia '98: Opportunities for Economic Development'. The ultimate goal was to increase awareness of the importance of mining to the economy of Nova Scotia and to garner support for future mineral development projects.

Mining Matters for Nova Scotia '98

In May 1998, the Department of Economic Development and Tourism (EDT) was approached to be a partner in the organization of the conference. EDT promoted the conference to Regional Development Authorities and Business Centres throughout the province. In addition, DNR and EDT invited a wide range of organizations to attend the conference, including municipal agencies, other provincial government departments, and economic development agencies. As in previous years, the Mining Society of Nova Scotia, Chamber of Mineral Resources of Nova Scotia and the Nova Scotia Prospectors Association were integral in the organization and implementation of the conference.

The 1998 Mining Matters conference was held at the World Trade and Convention Centre in Halifax on November 9 and 10, 1998. A total of 411 delegates attended the event, a record attendance in the more than 20 years that the department has hosted their annual fall conference!

Gisele Jacob, Vice President (Public Affairs) of the Mining Association of Canada, gave the keynote address on Tuesday, November 10. Ms. Jacob spoke about the importance of the mining industry to the Canadian economy and her involvement with the national *Mining Works for Canada* campaign. She reviewed some of the challenges currently facing the mining industry, including globalization of capital markets, liberalization of investment regimes, and rapidly changing technologies. Ms. Jacob summarized the many ways that mining is important to Canadians, accounting for a $26.2 billion contribution to the Gross Domestic Product.

Mining Matters for Nova Scotia '98 featured a commercial trade show with service and supply companies, a first for the annual conference. In addition, several mineral-producing companies, exploration companies and prospectors had displays in the exhibit area. More than 50 geoscientists from DNR, the Geological Survey of Canada, and local universities participated with exhibits highlighting current research in Nova Scotia.

Technical sessions were organized by the Mining Society of Nova Scotia and DNR and were held on November 9 and 10. Speakers represented several groups including the mineral industry, DNR, EDT, the Department of Agriculture and Marketing, and provincial Aboriginal groups. These sessions were very well attended, attesting to the high quality of the talks given. Presentations covered a wide range of topics including: the partnership between Georgia Pacific Corporation and Aboriginal Nations in developing a new gypsum mine in Melford; using zeolites to make kitty litter and much more; an overview of Nova Scotia's newest gold mine; development opportunities related to our famous fossil cliffs; the connection between aggregate sand deposits and cranberry bogs; reclamation activities at the former East Kemptville tin mine; developing community relationships at the Murchyville gypsum mine; current kaolin exploration in central Nova Scotia; and mineral-related opportunities associated with the Sable Offshore Energy Project.

A field trip was held on November 8 as part of the Mining Matters conference. The trip focused on the geology, mining and mineral exploration activities of central Nova Scotia and was organized by Dr. Ralph Stea. Approximately 40 people attended the trip.

The Honourable Kennie MacAskill hosted a Baron of Beef reception in the exhibit area on November 9. Mr. MacAskill spoke to the delegates about the importance of mining to Nova Scotia's economy. Following this he welcomed out-of-province delegates into the Order of Good Times, presenting them with commemorative certificates from the Government of Nova Scotia.

Assessment of Mining Matters '98

A questionnaire was circulated to delegates at the conference, to evaluate the effectiveness of the event and provide input for future changes. The response was very positive and strongly supported the new approach (Table 1). Of the 42 respondents to the questionnaire, 48% were attending the event for the first time. 98% of the respondents indicated that they were interested in attending the conference in 1999. On a rating scale of 1 (poor) to 5 (excellent) the respondents gave the Mining Matters conference a good or better rating (see Table 1).

Mining Matters for Nova Scotia '98: Opportunities for Economic Development provided an opportunity to spotlight the importance of the mining industry to a large, non-traditional client group. Initial response from the delegates was invariably positive and supportive of continuing this new focus for the conference in future.

Mining Matters '99

A committee is now working on plans for the Mining Matters '99 conference, to be held November 8 and 9, 1999, at the World Trade and Convention Centre. The partnerships that were initiated at last year's event will be expanded upon. This year's event will focus on the mineral-related opportunities that exist in Cape Breton Island, which may help offset the down-turn in the Cape Breton coal industry. The possibility of a field trip on Cape Breton Island is currently being investigated.

The Mining Matters conference not only serves our traditional clients in the mineral industry, but new clients as well. It provides an opportunity to showcase the importance of the mineral industry to the economic development of Nova Scotia. Keeping DNR's annual conference topical and poignant will ensure its future success.

Table 1. Evaluation of Mining Matters '98 conference.

Group	Mining	Exploration	Econ. Dev.	Fed./Prov.	Consultants	Service	University	Other	Total
Number of questionnaires	1	8	3	7	3	7	9	4	42
No. of 1st time attendees	1	0	2	3	2	3	6	4	48%
Length of conference OK?	yes-1	yes-8	yes-3	yes-7	y-2; n.a.-1	y-6; long-1	y-7;short-1	yes-4	y-93%
Willing to pay registration fee	yes-1	yes-4; no-4	yes-3	yes-5; no-2	yes-1; no-1	yes-5; no-2	yes-2; no-7	yes-2; no-2	y-55%
Interested in attending next year	yes-1	yes-8	yes-3	yes-7	y-2; poss.-1	yes-7	yes-9	yes-4	y-98%
Ratings									Avg.
Organization	4	4.1	4	4.2	4.5	4.3	4.4	4.7	4.3
Guided tours of disply areas	4	3.2	3.3	3.5	3.5	4.3	4.2	4	3.7
Trade show and geosc. displays	4	4	4	4	4.3	4.4	4.4	4.7	4.2
Oral presentations	5	3	4.3	3.9	4.5	4.3	4.2	4	4.1
Social functions	4	3.7	3.5	3	4	3.2	3.8	4.5	3.7
Venue for conference	n/a	4.1	4.7	4.5	3	4.3	4.3	4.7	4.2
Field trip	n/a	5	5	4	4	5	4.3	5	4.6
Average Score	4.2	3.9	4.1	3.9	4	4.3	4.2	4.5	
Ratings: 1-poor; 2-fair; 3-average; 4-good; 5-excellent									

Mineral exploration activity in Nova Scotia, 1998

P. D. McCulloch

Introduction

Monitoring of mineral exploration activity in Nova Scotia is coordinated through the Geoscience Information Services Section of the Mineral and Energy Resources Division by the author, who works out of the regional office in Stellarton, Pictou County. Regional Geologists of the Regional Services Branch offices in Coxheath (Don MacNeil), Truro (Melanie Haggart) and Bridgewater (Gordon Adams) assist in monitoring mineral exploration activity in their respective regions.

The monitoring process covers exploration activities throughout Nova Scotia and consists of visits to company offices and exploration sites, liaison with industry personnel, and the review of current assessment reports and other material submitted by industry. Liaison with industry allows the department to maintain an awareness of current exploration activities throughout the province. Assistance or advice is provided as necessary, and any drill core generated by mineral exploration activity is recorded as part of the monitoring process. This core may be recovered for archiving in the Drill Core Library in Stellarton when no longer required by the companies.

The Exploration Monitoring geologist is also responsible for auditing confidential assessment reports submitted in support of the renewal of exploration licences. In 1998, 137 assessment reports were received and audited for compliance with the Mineral Resources Regulations.

Mineral Exploration Activity

In 1998, mineral exploration in Nova Scotia continued at approximately the same level of activity as in 1997. Total field exploration expenditures are estimated at $6.0 million compared with $6.7 million in 1997 and $5.7 million in 1996 (Table 1, Fig. 1). Exploration was carried out for industrial minerals, base metals, gold and coal in a variety of geological environments throughout the province.

Preliminary data for the total number of general claims staked in 1998 show a decrease of 64.8% from the previous year to 9,000 claims (Table 1, Fig. 2).

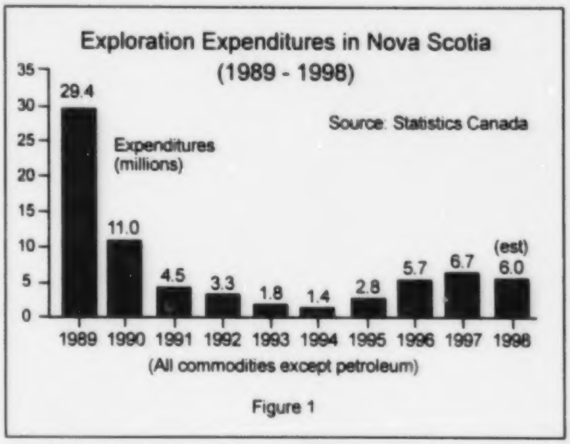


Figure 1. Exploration expenditures in Nova Scotia, 1989-98.

Preliminary figures indicate that 10,116 claims for all commodities were in effect at the end of 1998, represented by 575 exploration, coal, tailings and special licences covering an area of 163,757 ha or 1,637 km^2, approximately 3.0% of the total area of the province. The amount of exploration drilling decreased significantly in 1998 with a preliminary estimate of 12 500 metres compared with 24 500 metres in 1997 and 15 600 metres in 1996.

Approximately 228 companies and individuals held exploration interests (licences or options) in Nova Scotia in 1998, including 12 major, 9 junior and 38 private companies (Tables 2, 3 and 4). In addition, several mining lease holders carried out exploration on their leases or on unclaimed ground where these commodities did not require licences (e.g. limestone, gypsum). Organizations actively engaged in exploration during 1998 included 7 major, 3 junior and 17 private companies (Fig. 3, Table 5), as well as a number of individuals.

Industrial Minerals

Exploration and development work for industrial minerals was highlighted by continued interest in kaolin, silica sand, gypsum, zeolites and barite. Work primarily focused on the recent discovery of extensive kaolin and silica sand deposits in central mainland Nova Scotia, and

Table 1. Details of exploration and development activity in Nova Scotia, 1989-1998.

	1989	1990	1991	1992	1993	1994	1995	1996	1997	[p]1998
Total Exploration Expenditures ($)	21 436 000	11 025 000	4 532 000	3 300 000	2 300 000	1 400 000	2 843 000	5 752 000	6 700 000	6 000 000
Total Licences Issued (all categories)	987	753	642	507	594	670	697	1 120	1 018	575
Claims In Good Standing (new and reissued)										
General	21 831	17 460	17 071	11 157	9 504	13 737	15 859	33 435	25 589	9 000
Special (Order in Council)										
Salt and Potash	232	298	264	264	66	66	-	16	16	255
Coal	2 440	2 440	1 566	366	433	376	376	469	398	240
Tailings	0	116	116	94	146	146	146	146	146	-
Other	255	331	448	348	452	255	130	254	254	621
Uranium*	(1 200)	(1 200)	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)
Development	930	1 474	553	-	-	-	-	-	-	-
Total (excluding closures and uranium licences)	25 688	22 119	20 018	12 229	10 601	14 580	16 511	34 320	26 403	10 116
Total Area Held Under Licence										
ha	415 837	358 062	324 051	197 963	171 609	236 021	267 280	555 571	427 411	163 757
acres	1 027 520	884 760	800 720	489 160	424 040	583 200	660 440	1 372 800	1 056 120	404 640
Work Reported for Licence Renewals ($)	31 333 645	16 551 636	3 889 914	2 333 972	983 402	1 694 368	1 601 639	2 376 023	3 146 899	5 385 194
Number of Assessment Reports Received	303	176	132	75	62	84	111	114	137	137

[p] Preliminary figures for 1998

* Parentheses around uranium claims indicate ground alienation due to the uranium moratorium

December 31, 1998

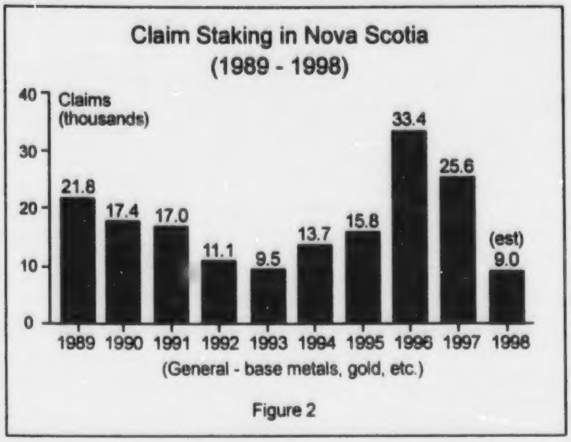


Figure 2. Claim staking in Nova Scotia, 1989-98.

continuing development work on gypsum deposits in northern mainland Nova Scotia and Cape Breton Island.

Work continued on a detailed evaluation of Cretaceous kaolin and silica sand deposits by Kaoclay Resources Incorporated in the Musquodoboit and Shubenacadie valleys of central mainland Nova Scotia. The company began work in the area in 1996 and recently completed large-diameter bulk sample coring, additional diamond-drilling, seismic surveys and process testing.

Georgia Pacific Corporation initiated a drilling program in 1997 to evaluate gypsum resources near Melford, Inverness County. The company continued with plans to begin production on the property in 1998. The deposit contains mineable reserves of 20 million tonnes of gypsum. Tusket Mining Limited completed additional development work on the Murchyville gypsum deposit in central mainland Nova Scotia and carried out preliminary quarrying operations during 1998.

In 1997, WTC Resources Limited began a detailed evaluation of the numerous high-quality zeolite occurrences in the North Mountain basalt along the Bay of Fundy in 1997. In 1998 the company carried out geological mapping, diamond-drilling, and analytical work on several of the occurrences.

Lynx Minerals Corporation recently began a detailed evaluation of the Scotsville barite deposits in the Lake Ainslie area, Inverness County. The area is host to a series of east-west barite and barite-fluorite veins that were worked intermittently from 1894 to 1934.

Maritime Mica Incorporated carried out diamond-drilling early in 1998 to evaluate mica and andalusite occurrences at Doughboy Point, Guysborough County. Titanium Corporation of Canada Limited initiated an evaluation of the titanium potential of heavy mineral sands in the Shubenacadie River near South Maitland, Hants County. CAG Enterprises Limited completed a trenching program for clay and silica sand at Flintstone Rock, Yarmouth County.

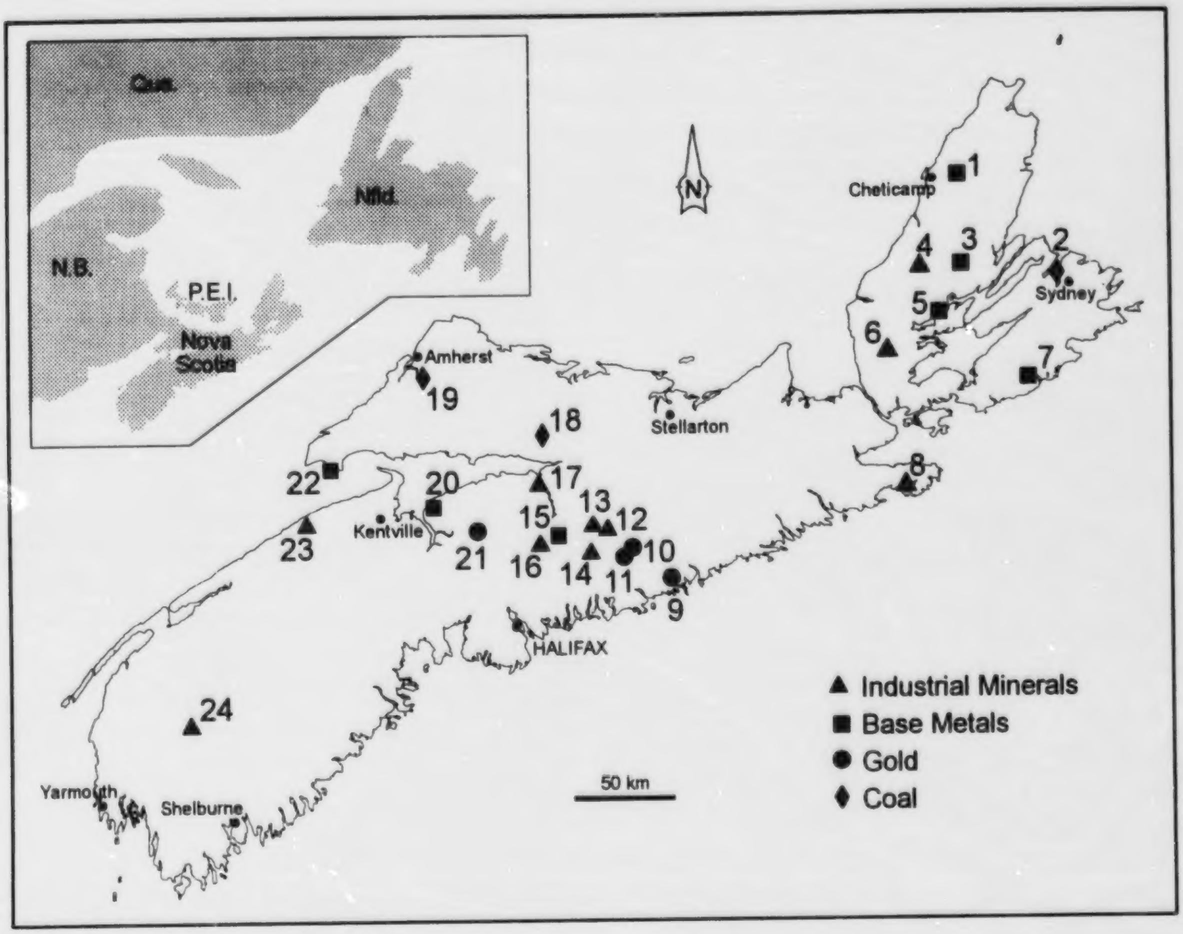
Base Metals

Exploration for base metals maintained a level of activity similar to 1997 and focused on areas of known mineral occurrences in the province. Exploration for base metals continued in the Carboniferous Windsor Group in northern mainland Nova Scotia and eastern Cape Breton Island. Exploration also continued in the Precambrian rocks of northern and southern Cape Breton Island.

Savage Resources Canada Limited continued to evaluate the feasibility of re-opening the former Gays River Zn-Pb mine in central mainland Nova Scotia. Recent activity on the property included de-watering the mine and underground development work. The deposit is hosted by Lower Carboniferous sediments of the Windsor Group, with *in situ* reserves of 2.4 Mt grading 8.6% Zn and 6.3% Pb. The company also carried out an exploration drilling program for base metals in the vicinity of the Jubilee Pb-Zn deposit at Little Narrows, Victoria County, during 1998.

Regal Goldfields Limited began exploration for gold and base metals in the Faribault Brook and Trout Lakes areas, Inverness County, in 1996 and recently completed additional diamond-drilling as part of their exploration program. Mountain Lake Resources Incorporated carried out exploration drilling for base metals in the Gold Brook area, Victoria County, and Phelps Dodge Corporation of Canada, Limited completed an exploration drilling program for base metals in the Stirling area, Richmond County.

Gold 'n Crystal Minerals completed additional work, including ground geophysical surveys and geochemical sampling, to evaluate the gold and base metal potential at Cap d'Or, Cumberland County. Geosearch completed additional work to evaluate the base metal potential of Carboniferous sediments in the Cheverie area, Hants County.


Que.
Nfld.
N.B.
P.E.I.
Nova Scotia
N
Cheticamp
Sydney
Amherst
Stellarton
Kentville
HALIFAX
Yarmouth
Shelburne
50 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
▲ Industrial Minerals
■ Base Metals
● Gold
♦ Coal

1. Regal Goldfields Ltd.
2. Brogan Mining Company Ltd.
3. Mountain Lake Resources Inc.
4. Lynx Minerals Corporation
5. Savage Zinc Incorporated
6. Georgia Pacific Corporation
7. Phelps Dodge Corp. of Canada Ltd.
8. Maritime Mica Inc.
9. Tangier Limited Partnership
10. Moose River Resources Inc.
11. Strikezone Minerals (Canada) Ltd.
12. Kaoclay Resources Inc.
13. Joe Richman
14. Tusket Mining Ltd.
15. Savage Resources Canada Ltd.
16. Kaoclay Resources Inc.
17. Titanium Corporation of Canada Ltd.
18. Berichan Resources Ltd.
19. Delta Coal Inc.
20. Geosearch
21. Roland Anthony
22. Gold'n Crystal Minerals
23. WTC Resources Ltd.
24. CAG Enterprises Ltd.

Figure 3. Mineral exploration programs in Nova Scotia, 1998.

Gold

The lower Paleozoic Meguma Group of southern mainland Nova Scotia continued to be a focus for gold exploration in 1998. In comparison to 1997, the level of activity for gold was down marginally.

Tangier Limited Partnership continued development work on the former Coxheath Gold Holdings property at Tangier, Halifax County, to determine the feasibility of re-opening the mine. The company completed milling and metallurgical tests during 1997 and was issued a mining permit in 1998 to begin underground mining operations.

Table 2. Major companies involved in mineral exploration in Nova Scotia, 1996-1998.

	1996	1997	1998	Office location in 1998
BHP Minerals Canada Limited	x	-	-	
Caledonia Mining Corporation	x	x		
Canada Tungsten Incorporated (formerly Canamax Resources Incorporated)	-	-		
Conwest Exploration Company Limited	-	-		
A. J. Perron Gold Corporation (formerly Deak Resources Corporation)	-	x	x	
Falconbridge Limited	-	-	-	
Fundy Gypsum Company	x	x	x	Windsor
Georgia Pacific Corporation	x	x	x	Sugar Camp
Granges Exploration Limited	-	-		
Lafarge Canada Incorporated	x	-	-	Brookfield
Little Narrows Gypsum Company Limited	x	x	x	Little Narrows
National Gypsum (Canada) Limited	x	x	x	Milford Station
Noranda Exploration Company Limited	-	-	-	
Phelps Dodge Corporation of Canada Limited	x	x	x	
Placer Dome Canada Limited	x			
Savage Resources Canada Limited	x	x	x	
W. M. C. International Limited	-	-	-	

x indicates work performed
- company inactive
blanks indicate that the company did not hold an exploration licence in that particular year

Table 3. Junior exploration companies in Nova Scotia, 1996-1998.

	1996	1997	1998	Office location in 1998
Altai Atlantic Mining Incorporated		x		
Acadia Mineral Ventures Limited	-	-		
Alterra Resources Incorporated (formerly Medyx Incorporated)	x			Truro
Ashgrove Energy Limited	-			
Atlantic Industrial Minerals Incorporated	x	x		Sydney
Corner Bay Minerals Incorporated	-	-	-	Cold Brook Station
Exploration Orex Incorporated	-	-	-	
Globex Mining Enterprises Incorporated		-	-	
Groundstar Resources Limited		-	-	
Heartland Resources Limited	-	-	-	Dartmouth
Jascan Resources Incorporated	-	-		
Mispec Resources Limited	x	x		Truro
Regal Goldfields Limited	x	x	x	
Roycefield Resources Limited	-	-	-	
RJZ Mining Incorporated		x	x	
WTC Resources Limited (parent company C_2C Mining Corporation)	-	x	x	Kentville

x indicates work performed
- inactive
blanks indicate that the company did not hold an exploration licence in that particular year

Table 4. Private exploration companies in Nova Scotia, 1996-1998.

	1996	1997	1998	Office location in 1998
AEC West Limited		-		
Aurora Gold Corporation		-		
Aurion Minerals Limited	x			Halifax
Beaver Exploration Incorporated		-		
Benrock Limited	-			Antigonish
Berichan Resources Limited	x	x		
Burnt Point Resources Incorporated	x	x	x	Halifax
C.A.G. Enterprises Limited	-	x	-	Antigonish
Cannova Goldfields Incorporated	x	x		
CAN-SCO Enterprises		-		Halifax
Cape Minerals Limited			-	
Champlain Goldfields Incorporated		-		
Champlain Resources Incorporated		x		
Cobequid Life Sciences Limited	-	-	-	
Conrad Brothers Limited		-		Dartmouth
D&D Metal Detectors Limited		-		
Dufferin Resources Incorporated	-	-	-	Halifax
Ellsin Resources Incorporated	-	x	x	
Gallant Aggregates Limited		-		
Gammon Lake Resources Incorporated	x	x	x	Halifax
Geocol Mining and Exploration	x	-		Dartmouth
Geosearch	x	x	x	Sackville
Ghost Town Gold Corporation		-		
Giant Meguma Holdings	-	-	-	Halifax
Gold Bank Resources Limited	x	-		
Gold 'n Crystal Minerals	x	x	x	East Advocate
Golden Ace Mineral Explorations Limited		-	-	
Goliath Copperfields Limited			x	
Groundstar Resources Limited		-	-	
Gusto Resources Limited	-	-	-	Halifax
Halifax Goldfields Incorporated		-		
Hansone Limited		-		
Highland Range Minerals Limited	x	x	x	
Huntington Explorations Incorporated			-	
Intragaz & Company Limited Partnership			-	
James Henry & Associates	-	-	-	
John Logan Enterprises Limited		-	-	
Jubilee Minerals	-	-	x	Bedford
Kaoclay Incorporated	x	x	x	Milford Station
Kelly Rock Limited	x	-	-	Sydney
Lake Annis Properties Limited			-	
Little Lake Gold Mines Limited	x	x	-	Dartmouth
Lodestone Limited	x	-		Halifax
Maritime Mica Incorporated			x	
Mercator Geological Services Limited			x	Dartmouth
Mik Vic Investments Limited		-		
Moose River Resources Incorporated	x	x		
Mosher Limestone Company Limited	x	-		Upper Musquodoboit
Mountain Lake Resources Incorporated			-	
Murray Brook Resources Incorporated		-		
New Road Resources Limited			-	
North Cape Breton Resources Limited	x	-	x	
Pan East Petroleum Corporation (formerly Pan East Resources Incorporated)	-	-	-	
Prodigy Resources Incorporated	x	x		
Remoscan Limited	x	x	-	

Table 4. Continued.

	1996	1997	1998	Office location in 1998
Renfrew Gold Contracting	x	x		
Renfrew Holdings Limited			-	
The Shaw Group Limited (formerly L. E. Shaw Limited)	x	-	-	Lantz
Scotia Slate Products Limited		-		
Southfield Resources Limited		-		
Springhill Coal Mines Limited	-			
Strikezone Minerals (Canada) Limited			x	
Tangier Limited Partnership (formerly Tangier Mining Incorporated)	x	x	x	Tangier
Tanner Engineering Limited	x			
Tri-Explorations Limited	x	x	x	Halifax
True Metallic Explorations		x	x	
Tusket Mining Incorporated	x	x		Bedford
Victoria Mining Services Limited	-	-		
Votix Corporation Limited	-	x	x	Trenton
Wabana Explorations Incorporated	x	x		

x indicates work performed

- inactive

blanks indicate that the company did not hold an exploration licence in that particular year

Moose River Resources Incorporated recently completed a detailed evaluation of the Touquoy deposit at Moose River, Halifax County. Regal Goldfields Limited entered into an option agreement with the company in October and plans to continue exploration and development work on the deposit in 1999. Current reserves are estimated at 5.74 million tonnes grading 2.2 g Au/t.

Strikezone Minerals (Canada) Limited, in an option agreement with Ellsin Resources Incorporated, continued a detailed evaluation of the Lake Charlotte gold property, Halifax County. A number of exploration programs were also undertaken on several properties throughout the Meguma Group by individuals and private interests.

Coal

Exploration for coal focused on the Carboniferous rocks of northern mainland Nova Scotia and eastern Cape Breton Island. Berichan Resources Limited continued a detailed evaluation of coal resources in the Cottam Settlement area east of Debert, Colchester County, and began development work on the property during the fall. Brogan Mining Company Limited initiated a bulk sampling program for coal at Little Pond, Cape Breton County, and Delta Coal Incorporated continued an evaluation of coal resources in the Chignecto area, Cumberland County.

Table 5. Mineral exploration programs in Nova Scotia, 1998.

COMPANY/INDIVIDUAL	LOCATION	COMMODITY	PROGRAM	STATUS
Berichan Resources Limited	Cottam Settlement, Colchester County	Coal	Preliminary development work	Ongoing
Brogan Mining Company Limited	Little Pond, Cape Breton County	Coal	Trenching, bulk sampling	-
CAG Enterprises Limited	Flintstone Rock, Yarmouth County	Clay, silica sand	Trenching	-
Delta Coal Incorporated	Chignecto, Cumberland County	Coal	Engineering studies	Ongoing
Geosearch	Cheverie, Hants County	Base metals	Prospecting, geochemical sampling	Ongoing
Georgia Pacific Corporation	Melford, Inverness County	Gypsum	Preliminary development work	Ongoing
Gold 'n Crystal Minerals	Cap d'Or, Cumberland County	Copper, gold	Prospecting, geochemical sampling	Ongoing
Joe Richman	Elmsvale, Halifax County	Clay, silica sand	Prospecting, diamond-drilling	-
Kaoclay Resources Incorporated	Middle/Upper Stewiacke	Clay, silica sand	Diamond-drilling	Ongoing
	Middle/Upper Musquodoboit	Clay, silica sand	Diamond-drilling, bulk sampling geophysical surveys	Ongoing
	Nine Mile River/Shubenacadie	Clay, silica sand	Diamond-drilling	-
Lynx Minerals Incorporated	Scotsville, Inverness County	Barite	Geochemical sampling	Ongoing
Maritime Mica Incorporated	Doughboy Point, Guysborough County	Mica, andalusite	Diamond-drilling	-
Titanium Corporation of Canada Limited	South Maintland, Hants County	Mineral sands	Prospecting, geochemical sampling	Ongoing
Moose River Resources Incorporated	Moose River, Halifax County	Gold	Evaluation of Touquoy deposit	On Hold
Mountain Lake Resources Incorporated	Gold Brook, Victoria County	Base metals	Diamond-drilling	Ongoing
Phelps Dodge Corp of Canada Limited	Stirling, Richmond County	Base metals	Diamond-drilling	Completed
Roland Anthony	McKay Section, Hants County	Gold	Trenching	-
Regal Goldfields Limited	Faribault Brook, Inverness County	Base metals	Diamond-drilling	Ongoing
Savage Resources Canada Limited	Gays River, Halifax County	Base metals	Underground exploration	Ongoing
Savage Zinc Incorporated	Little Narrows, Victoria County	Base metals	Diamond-drilling	-
	Washabuck, Victoria County	Base metals	Diamond-drilling	-
Strikezone Minerals (Canada) Limited	Lake Charlotte, Halifax County	Gold	Geophysical surveys, geochemical sampling	-
Tangier Limited Partnership	Tangier, Halifax County	Gold	Preliminary development work	Ongoing
Tusket Mining Incorporated	Murchyville, Halifax County	Gypsum	Mine development	Ongoing
WTC Resources Limited	Ogilvie, Kings County	Zeolites	Geological mapping, diamond-drilling	Ongoing
	Huntington Point, Kings County	Zeolites	Geological mapping diamond-drilling	Ongoing

Drill Core Library programs, 1998

J. M. McMullin, W. Palmer, D. Weir and J. Horton

Introduction

The departmental Core Library is based in Stellarton, Pictou County (NTS 11E/10), where a modern facility houses most of the department's drill core. Drill core and other sample materials are received from mineral exploration and development projects conducted by the private sector as well as from departmental field work. A large collection of drill core and other reference material is thereby preserved and made available to exploration and research geologists, in order that they may enhance the knowledge of Nova Scotia's geology and mineral resources. In addition to drill core, sample media available for further work include well-cuttings from oil and gas drilling, rock slabs and geochemical samples (silt, till, soil, lake sediment and biogeochemical samples). All core is available for examination by interested parties and may be sampled subject to certain constraints and conditions. Logs, reports and maps are also available for consultation. It is recommended that all visitors give advance notice (preferably a minimum of 24 hours) of an intended visit to ensure the availability of staff, core and equipment. Staff may be contacted by phone at **902-752-4842** or **902-755-7038**, by fax at **902-755-7186** or by e-mail at **corelib@fox.nstn.ca**.

Facilities and Services

The main Core Library facility is centrally located in Nova Scotia, 2 km off the Trans-Canada Highway at 105 - 109 Acheron Court in the Stellarton Industrial Park, Pictou County. Five purpose-built buildings give the facility a total of 4000 sq. m, which includes 300 sq. m of laboratory space and 120 sq. m of office space. Free parking is available at the door. Unmanned storage buildings are located at West Paradise (the Eden Building) near Bridgetown, Annapolis County, and in the Scotia Subdivision of the Debert Industrial Park, Colchester County.

Core is mostly stored in standard 5 ft. long wooden core boxes (15 to 25 ft. capacity, depending on core size). Boxes of core are stored on custom-made wooden pallets, which are stacked in rows in the unheated storage areas. When required, individual pallets are retrieved from storage and transferred by fork-lift to the core examination labs, where the core boxes may be laid out for viewing, using benches, portable stands, or the floor. A large paved yard also serves as a core box layout area during good weather. The Core Library is equipped with binocular microscopes, hand-held UV lights, photographic equipment, scales, core-splitters and diamond saws.

A small reference library area is set up on the ground floor with tables, chairs and a microfiche reader-printer, available for the use of both clients and staff. All non-confidential Assessment Reports and all Open File Reports, Open File Illustrations and Open File Maps are available on microfiche, and paper copies of most of the reports, papers, maps and other mineral-related NSDNR publications are available for reference.

Two interlinked PC-based databases contain information related to drilling done in the province and to core available at the Core Library. These databases are maintained by staff at the Core Library, and can be searched by staff for any information requested by clients. Drillholes with known geographic co-ordinates can also be displayed as map plots (video screen or print) using the department's ArcView®-based geographic information system (GIS). To take better advantage of GIS technology, computer equipment was upgraded in early 1998 by purchasing a Dell Pentium II 300MMX with 64 MB RAM, a CD-ROM, a fax-modem, and a 17 inch monitor. Other computers consist of desktop 486s and Pentiums, and a notebook 486. Two 100 megabyte Zip drives provide back-up capability and storage for GIS files and database files. Modems on four machines provide the capability for e-mail communication.

In 1998, the Minerals and Energy Branch completed the transfer of other Branch activities to the Core Library from the former Mines Building on Bridge Avenue in Stellarton. The two remaining staff geologists at the Mines Building (Kevin Gillis and Paul McCulloch) relocated to the Core Library in mid-year. The majority of the equipment, furniture and materials used or stored at the Mines Building was either moved to the Core Library or set aside for disposal. During the year, plans were drawn up and submitted to Public Works for the provision of adequate office, laboratory and library space at the Core Library to accommodate the additional demands resulting from the move out of the Mines Building.

Staffing changes at the Core Library in 1998 included the retirement of geologist Bill Palmer at the end of May, and the departure of Jim DeWolfe early in the year on a leave of absence. John Horton's position as Mineral Technician was upgraded to Mineral Technologist. At year-end, technical and professional staff operating the Core Library programs consisted of a mineral technologist, one project geologist and a supervising geologist. David Cowan, geology student at Francis Xavier University in Antigonish., was employed for the summer, and continued on a part-time basis during the remainder of the year.

Holdings and New Acquisitions in 1998

Total core in storage in all locations at the end of 1998 was approximately 640 000 m. In addition to core, the Core Library maintains a set of drill cuttings (chips) from many of the wells drilled for oil and gas in Nova Scotia and its offshore areas. Also, a great variety of different types of samples and sample collections are stored in Core Library facilities, ranging from materials collected in the field by staff, including geochemical sample suites, rock slabs and till samples, to collections of soil and rock samples donated by exploration companies. Core donated to the department is sometimes delivered by the donating company, but more usually the core is collected from its field location by Core Library staff using departmental vehicles.

In 1998, approximately 16 445 m of drill core from 267 drillholes were received at the Core Library. All of the core was generated from exploration work carried out by the private sector from 1990 to 1998 (Table 1).

1998 Activity

The majority of clients at the Core Library are either geological staff of the Minerals and Energy Branch or are exploration geologists working in the private sector. The level of activity at the Core Library facilities often reflects the activities of these two client groups. Table 2 shows statistics related to clients' use of the facilities.

Drill Core Evaluation

As time and resources permit, packages of drill core from selected areas or projects are evaluated in order to try to reduce the total amount of core from a particular area while still maintaining the integrity and value of the collection. The evaluation process also ensures that core retained in the permanent collection is properly identified and documented and that it meets a variety of criteria based on the needs of clients and staff. Core which does not meet these criteria can be removed from the collection after consultation with interested parties. Core may be recommended for disposal for any or all of the following reasons: poor or unuseable condition, excessive sampling, inadequate labelling, duplication, poor documentation, or low geological interest from either a research or mineral evaluation perspective. All these criteria require that a careful assessment be made by an experienced geologist before recommendations are put forward, usually in consultation with other geologists familiar with the drilling project or the area under study.

All evaluations and recommendations are supported by written reports providing detailed reasons for retaining or disposing of core. Core that has been recommended for disposal is kept on hand pending receipt of input from interested parties and a final decision to discard. Any core that is to be removed from the collection will be photographed, and surplus core in good condition will be offered to university geology departments and others as an alternative to being discarded.

Photography of drill core provides visual documentation, enabling staff and clients to quickly and easily preview sections of interest and providing a record for retention even after the core itself has been discarded. The photographic medium used is 35 mm colour slides, which can be projected to full size in natural colour. Core is usually photographed during the evaluation process, when the core has been straightened up and correctly identified and labelled, but it can be done at any time, depending on the need.

Future plans include the acquisition of a digital electronic camera to replace the traditional film-based camera. Electronic images will then be incorporated into the databases, eliminating the need for the more costly and cumbersome slide processing and storage. Use of this technology will provide clients with the ability to preview core when they receive custom listings of core either on diskette or on-line. Image resolution of digital cameras, however, is not yet as good as photographic film and digital memory requirements are very large.

During the first part of 1998, evaluation and photography of core was continued by Bill Palmer, but his retirement at the end of May left this position vacant and no further progress was made.

Additional photography was carried out on core from Moose River Gold Mines, Halifax County (Seabright Resources Ltd., 1987-88), and from Goldenville, Guysborough County (Goldenville Explorations Ltd., 1983). Preliminary evaluation and photography was carried out on core drilled at Harrigan Cove, Halifax County, by Quebec Uranium Mining Corporation in 1974 and Torene Gold Explorations Ltd. in 1987, and at Goldboro, Guysborough County, by Onitap Resources Inc. in 1984.

Other packages of core received in the first half of 1998 were also sorted and recorded, including core drilled by RJZ Mining in the Como Lake and Beaver Dam areas of Halifax County, by Regal Goldfields Ltd. in the Cheticamp area, Inverness County, and by Votix Corporation in the Dominique (Plymouth) area of Yarmouth County. Photo albums and a catalogue of drill core photography were updated to provide staff and clients access to these reference materials.

Core Library Databases and GIS

The Core Library maintains two databases containing information on drilling in Nova Scotia, the Drillholes Database and the Drill Core Database.

The Drillholes Database provides information on drilling related to mining, mineral or hydrocarbon exploration and development, or geological investigations. The database provides basic information on each drillhole, such as location (including claim reference map, tract and claim, latitude and longitude, and UTM co-ordinates), depth of hole, year drilled, exploration company, drilling contractor, types of mineralization, and references to assessment reports and other source documents. This database is updated on a continuing basis with information from newly released assessment reports and other sources.

The Drill Core Database provides information on all drill core that the Core Library has in its collection, including operational data such as the storage location details and a record of usage and sampling. Much of the basic drillhole information is common to both databases, so they have been linked electronically for greater efficiency. The Drill Core Database was first developed in 1990 on a personal computer using Advanced Revelation® database software and is being continuously developed and updated.

These databases can be custom searched for clients and staff by any combination of fields to produce either a printed copy or an electronic file with the required information. For example, the databases may be searched by place name, company name, drillhole number, map sheet, mineralization or year, or by various combinations of these fields.

The Drillholes Database originated in the Halifax office but is now maintained and updated with current informaton by Donald Weir in the Core Library in Stellarton. At the beginning of 1998 the database contained 21,314 drillhole records, and during the year an additional 127 records were indexed. These records will be added to the database following completion of proofing and verification.

The Drill Core Database is updated daily, with a total of 107 additional records being added during the year. At the end of December 1998 it contained 7340 records of which 4615 are linked with the Drillholes Database. Where records are linked or related, the information in both databases on a particular drillhole can be accessed through either database. Some records remain unlinked because the lack of documentation in assessment reports or open file reports precludes their inclusion in the Drillholes Database.

An application has been set up on the public access computer using OpenInsight® for Workgroups software (Revelation Technologies) which facilitates information searches in the Drillholes and Drillcore Databases by the use of on-screen prompts. A geographic information system (GIS) program is in use at the Core Library, with the Advanced Revelation® database files being added to ArcView® as dBASE files (tables). Drillholes can be plotted in ArcView® using Eastings and Northings as X and Y co-ordinates. Digital versions of the 1:500 000 Geology Map of Nova Scotia and the 1:50 000 NTS maps are available for use with the Drillholes Database. The Drillholes Database can be searched in ArcView® from any of the fields or by geographic features on the maps. Drillholes of interest can be highlighted on these maps and this information and the map can be printed on a Hewlett-Packard DesignJet 250C plotter providing plots up to 22 x 34 inches.

Drill Logs of Government Core Drills

The final edition of this publication will be a multi-year compilation covering the period from 1987 to the termination of the department's drilling activities in October 1996. It will contain abbreviated geologist's logs instead of the driller's logs used in previous editions, and will contain more detail relevant to each drill project. Most of the relevant information was gathered and compiled in prior years, but no further progress was made on this project during 1998.

Table 1. Drill core received at the Core Library, January - December 1998.

NTS	Company	Year Drilled	Commodity or Project	Location	County	No. of Holes	Hole Designation	Core Size	Total Metres	Total Feet
11D/14C 11E/03B	Can-Nova Goldfields Inc	1997	Zinc	Far Brook	Halifax	3	FB-97-1 to 3	NQ	396.5	1300
11D/14D 11E/03A	Westminer Canada Ltd	N/D	Base metals	Murchyville	Halifax	3	MCH-1 to 3	NQ	194.6	638
11E/02	RJZ Mining	1997	Gold	Beaver Dam East	Halifax	3	BDE-97-1 to 3	NQ	403.3	1323
11E/02	RJZ Mining	1997	Gold	Como Lake	Halifax	13	CL-97-1 to 13	NQ	1527.5	5010
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Chaswood	Halifax	5	CH-97-9 to 13	HQ	181	594
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Chaswood	Halifax	4	FR-97-1 to 4	HQ	176	577
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Elmsvale	Halifax	2	BR-97-33, 34	HQ	51.5	169
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Elmsvale	Halifax	1	MRB-97-32A	HQ	96	315
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Elmsvale	Halifax	1	MRM-97-35	NQ	0.5	2
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Elmsvale	Halifax	6	RR-97-22 to 29	HQ, NQ	460	1509
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Elmsvale	Halifax	1	RW-97-28	HQ	21	69
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	1	ER-97-12	HQ	18	59
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	3	GR-97-17 to 20	HQ	86.9	285
11E/03A	Kaoclay Resources Inc	1997	Kaolin, Silica sand	Middle Musquodoboit	Halifax	23	GTS-97-12 to 41	HQ	370.4	1215
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	3	HK-97-14 to 16	HQ	82.2	270
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	2	HR-97-30, 31	HQ	24.5	80
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	1	MMR-97-21	HQ	16.5	54
11E/03A	Kaoclay Resources Inc	1997	Kaolin silica sand	Middle Musquodoboit	Halifax	4	SG series	HQ	67.9	223

Continued...

Table 1. Continued.

NTS	Company	Year Drilled	Commodity or Project	Location	County	No. of Holes	Hole Designation	Core Size	Total Metres	Total Feet
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	15	SG-97-01 to 22	HQ	159.2	522
11E/03A	Kaoclay Resources Inc	1998	Kaolin, silica sand	Middle Musquodoboit	Halifax	68	SG-98-23 to 95	HQ	1469.5	4820
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	1	SPR-97-24	HQ	29	95
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	6	SR-97-5 to 9, 18	HQ	235	771
11E/03A	Kaoclay Resources Inc	1997	Kaolin silica sand	Middle Musquodoboit	Halifax	18	SPA-97-1 to 25	HQ	190.7	625
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	1	SRC-97-13	HQ, NQ	128.6	422
11E/03A	Kaoclay Resources Inc	1997	Kaolin, silica sand	Middle Musquodoboit	Halifax	2	SRT-97-10, 11	HQ	70	230
11E/03A	Westminer Canada Ltd.	1991/92	Base Metals	Glenmore	Halifax	4	GLM-1 to 4	NQ	557.6	1829
11E/03B	Westminer Canada Ltd.	1991	Base Metals	Meadow Brook	Halifax	2	CMB-1 & 2	NQ	363.6	1192
11E/04A	Westminer Canada Ltd.	1990	Base Metals	Nine Mile River	Hants	1	NMR-1	NQ, BQ	207.9	682
11E/05A	Westminer Canada Ltd.	1992	Base Metals	Noel Lake	Hants	4	NOL-1 to 4	NQ	252.4	828
11E/06A	Westminer Canada Ltd.	1990	Base Metals	Smithfield	Colchester	13	SMF-1 to 11	NQ, BQ	1749.2	5737
11E/07B	Westminer Canada Ltd.	1991	Base Metals	Glenbervie	Colchester	6	PEM-1 to 6	NQ	454.3	1490
11E/12B	Alterra Resources Inc	1996	N/D	Collingwood	Cumberland	1	CW-96-5	NQ	116.4	382
11F/06A	Maritime Mica Inc	1998	Andalusite	Doughboy Point	Guysborough	15	MM-98-1 to 15	BQ	575.5	1888
11F/11C	Westminer Canada Ltd	1992	Base Metals	Sugar Camp Lake	Inverness	2	SCL-12, 13	NQ, BQ	547.5	1796
11F/15C	Westminer Canada Ltd	1993	Base Metals	Jubilee	Victoria	6	JLN-1 to 6	NQ	1186.4	3891
11K/02B	Westminer Canada Ltd	1993	Base Metals	Upper Washabuck	Victoria	1	JLN-7	NQ	39.6	130
11K/02C	Westminer Canada Ltd	1992	Base Metals	Middle River	Victoria	3	MIR-1 to 3	NQ, BQ	415.7	1363
11K/10B	Highland Range Minerals Ltd	1995/96	Gold, silver base metals	Faribault Brook	Inverness	15	HR-95-1 to HR-96-15	BQTK, NQ	1564.9	5133
20O/16A	Votix Corporation Ltd	1997	Indium, Tin, Zinc	Plymouth	Yarmouth	5	D-97-1 to 5	NQ	258.9	849
11L5/12	PEI Energy	1997/98	Coal	Spring Valley	Prince, PEI	1	SV-1	HQ, NQ	1699.2	5571
					TOTALS	**267**			**16 444.8**	**53,938**

Table 2. Core Library statistics, 1994-1998.

	1994	1995	1996	1997	1998
Clients					
Staff / Non-staff	44 / 98	53 / 83	58 / 117	36 / 93	43 / 160
Total	**142**	**136**	**175**	**129**	**203**
User-days					
Staff / Non-staff	102 / 220	77 / 165	83 / 178	54 / 183	76 / 284
Total	**322**	**242**	**261**	**237**	**360**
Core examined	412	285	178	295	263
Samples taken	1 085	449	442	439	718
Drill core received	238	119	75	41	267
Metres of core received	27 345	11 040	4 542	3 746	16 445

Parallels between paleoplacer development in northern Nova Scotia and southern New Brunswick

R. F. Mills

Introduction

The potential for Upper Carboniferous rocks in northern Nova Scotia and southeastern New Brunswick to host paleoplacer gold deposits is being examined in light of new discoveries made in New Brunswick. Recent mapping has led to a better understanding of strata in the area (Johnson and MacLeod, 1998). Upper Carboniferous rocks are present in the Sackville Subbasin of New Brunswick and the Cumberland Basin of northern Nova Scotia (Fig. 1). Johnson and MacLeod (1998) observed a relationship between local geochemical gold

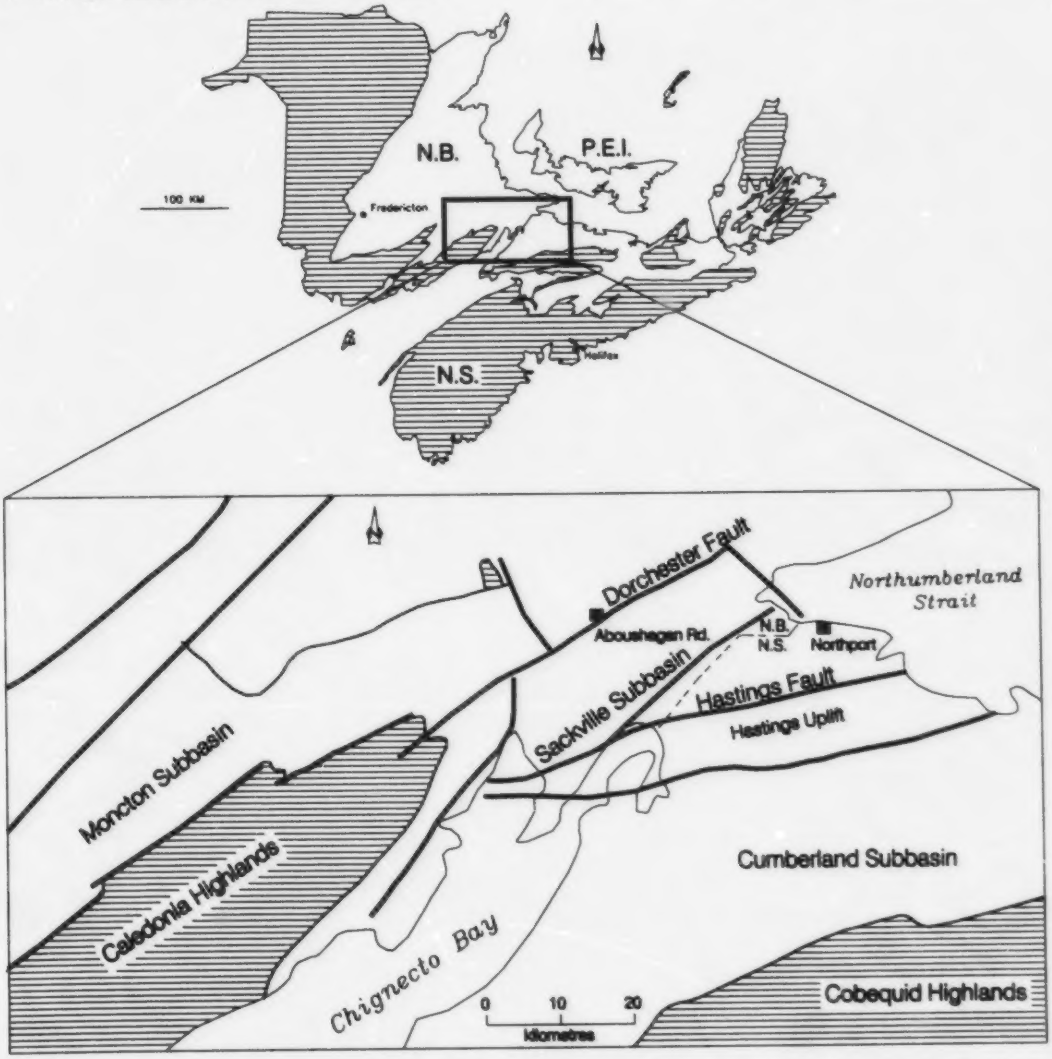

N.B.
P.E.I.
N.S.
100 KM
Fredericton
Halifax
Dorchester Fault
Northumberland Strait
Aboushagan Rd.
N.B.
N.S.
Northport
Sackville Subbasin
Hastings Fault
Hastings Uplift
Moncton Subbasin
Caledonia Highlands
Cumberland Subbasin
Chignecto Bay
0
10
20
kilometres
Cobequid Highlands

Figure 1. Location of the (New Brunswick) Sackville Subbasin in relation to major regional topography (after Johnson and MacLeod, 1998).

anomalies and underlying basement topography. This has lead to an interpretation that heavy mineral paleoplacer deposition is governed by a combination of paleotopographic and stratigraphic controls. Laterally equivalent rocks in Nova Scotia have displayed anomalous gold concentrations in stream sediments near the village of Northport, Cumberland County (Miller, 1987). Gold has also been panned from sand at Northport beach (Milner, personal communication, 1989).

Regional Geology

The oldest basement rocks in the region are Proterozoic gneiss and schist, and lower Paleozoic volcanic and sedimentary rocks of the Caledonia Highlands in New Brunswick and the Cobequid Highlands in Nova Scotia (Donohoe and Wallace, 1982) (Fig. 2). The basement rocks are overlain by Silurian to Devonian metasedimentary rocks, some with intercalated volcanics. These rocks are overlain by fine- to coarse-grained, clastic sediments of the Early Carboniferous Horton Group. The top of the stratigraphic sequence includes Lower to Upper Carboniferous rocks of the Windsor, Mabou, Cumberland and Pictou groups (Ryan *et al.*, 1990), representing evaporitic and basin infill sequences consistent with marine regression, followed by a molassic sequence of coal measures and redbeds.

Northport is underlain by the Pictou Group. These rocks consist of silty to sandy, sometimes coarse-grained conglomerates representing a fluvial basin-fill sequence. Exposure at Northport is poor, and much of the area is overlain by thick surficial deposits.

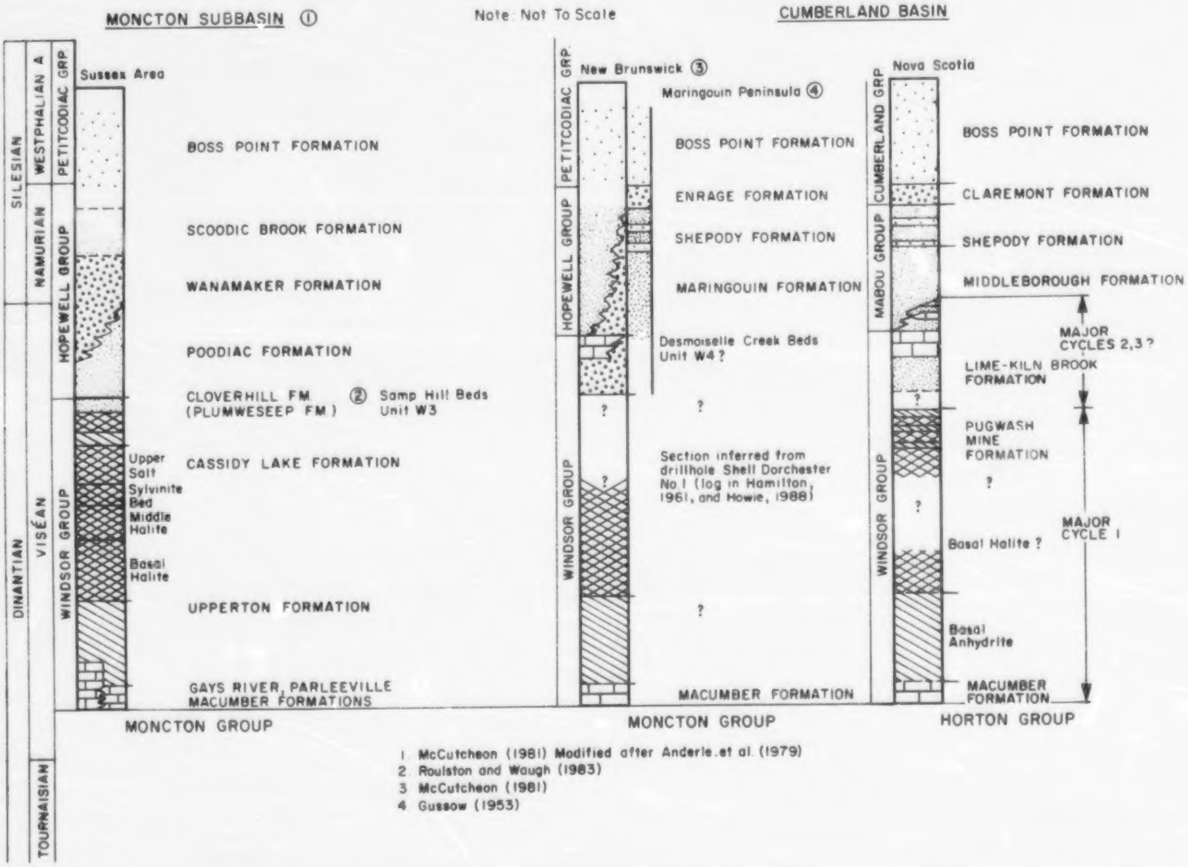

MONCTON SUBBASIN ①
Note: Not To Scale
CUMBERLAND BASIN
SILESIAN
WESTPHALIAN A
NAMURIAN
DINANTIAN
VISÉAN
TOURNAISIAN
PETITCODIAC GRP.
HOPEWELL GROUP
WINDSOR GROUP
Sussex Area
BOSS POINT FORMATION
SCOODIC BROOK FORMATION
WANAMAKER FORMATION
POODIAC FORMATION
CLOVERHILL FM. (PLUMWESEEP FM.)
② Samp Hill Beds Unit W3
Upper Salt
Sylvinite Bed
Middle Halite
Basal Halite
CASSIDY LAKE FORMATION
UPPERTON FORMATION
GAYS RIVER, PARLEEVILLE MACUMBER FORMATIONS
MONCTON GROUP
New Brunswick ③
Maringouin Peninsula ④
BOSS POINT FORMATION
ENRAGE FORMATION
SHEPODY FORMATION
MARINGOUIN FORMATION
Desmoiselle Creek Beds Unit W4 ?
?
Section inferred from drillhole Shell Dorchester No.1 (log in Hamilton, 1961, and Howie, 1988)
MACUMBER FORMATION
MONCTON GROUP
Nova Scotia
CUMBERLAND GRP.
MABOU GROUP
BOSS POINT FORMATION
CLAREMONT FORMATION
SHEPODY FORMATION
MIDDLEBOROUGH FORMATION
MAJOR CYCLES 2,3 ?
LIME-KILN BROOK FORMATION
PUGWASH MINE FORMATION
Basal Halite ?
MAJOR CYCLE I
Basal Anhydrite
MACUMBER FORMATION
HORTON GROUP
1 McCutcheon (1981) Modified after Anderle et al. (1979)
2 Roulston and Waugh (1983)
3 McCutcheon (1981)
4 Gussow (1953)

Figure 2. Table of formations for rocks in the Nova Scotia - New Brunswick border region (from Ryan and Boehner, 1994).

Regional Gold Anomalies and Paleoflow Association

Paleoplacer depositional models based on contact relationships have been common for many years and have been reviewed by Boyle (1987). A sedimentary model for deposits similar to those at Northport has been postulated in north-central Saskatchewan (Leckie *et al.*, 1998) where Cretaceous sediments of the Mannville Group display anomalous gold concentrations above a lithologic contact interpreted as an unconformity. The Cretaceous rocks above this unconformity record paleocurrent directions that indicate a clastic provenance from a suitable (Canadian shield) source.

Understanding the flow directions of ancestral streams that provided conduits between gold-bearing source rocks and sites of deposition is essential to exploration. In southern New Brunswick, paleoflow has been established for regional current directions (Gibling *et al.*, 1991). These regional directions suggest that rocks in the Northport area originated in the Caledonia Highlands, to the west-southwest of Northport (Johnson and MacLeod, 1998). Local paleochannels are believed to have also developed with sediment finding its way into the Moncton Subbasin from adjacent highland areas, including the Westmoreland Uplift (Fig. 3). The highland areas would provide suitable source rocks for paleoplacer gold deposition (Johnson and MacLeod, 1998).

Regional paleocurrent directions in the western part of the Cumberland Basin are from west-southwest close to the New Brunswick border, with a more northerly flow in the eastern Cumberland Basin, originating from the Cobequid Highlands (Fig. 4). Regionally, the Carboniferous basin-fill was derived from the Caledonia and Cobequid highlands, for the most part. These rocks are host to several small gold showings that would provide a suitable source for reconcentrated material (Northcote *et al.*, 1989).

Gold Anomalies at Northport and Southeastern New Brunswick

Geologist Michael W. Milner discovered that free gold could be panned from beach sediments at Northport in 1979 (Milner, personal communication). This occurrence was subsequently confirmed when a provincial government survey of stream sediment geochemistry revealed Northport as the location of a 99th percentile gold anomaly (Fig. 5). Considering the geology in the vicinity of Northport, with no known source of gold, this anomaly is considered to be remarkably strong. Three stream sediment samples taken from the area returned concentrations of 850 ppb, 806 ppb and 46 ppb, respectively, from material sieved smaller than the -230 mesh size (Mills, 1989). The 99th percentile threshold level for gold in this dataset, including the Cobequid Highlands, is 14 ppb. The bedrock source of the anomaly

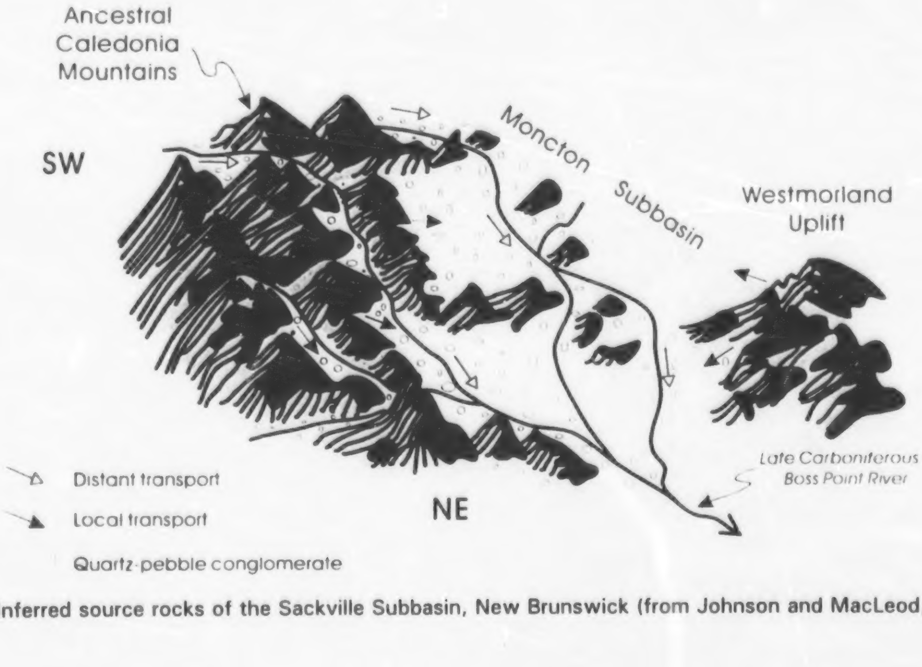

Ancestral Caledonia Mountains
SW
Moncton Subbasin
Westmorland Uplift
Late Carboniferous Boss Point River
NE
Distant transport
Local transport
Quartz-pebble conglomerate

Figure 3. Inferred source rocks of the Sackville Subbasin, New Brunswick (from Johnson and MacLeod, 1998).

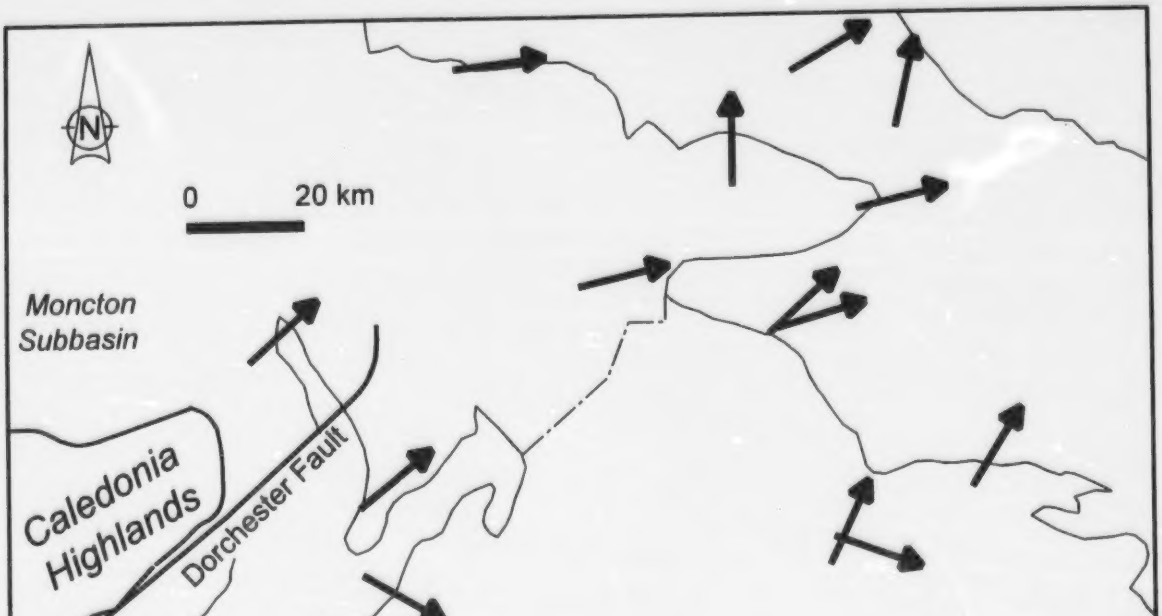


Figure 4. Paleocurrent flow directions in the Cumberland Basin, Nova Scotia (after Ryan and Boehner, 1994).

has never been located, but the same stream that yielded a sample with 850 ppb gold was sampled 2.2 km upstream from this location and returned a level below the detection limit of 5 ppb (Fig. 6).

Scanning electron microscope (SEM) images (Fig. 7) of gold panned from sediment at Northport beach reveal abraided grains showing some degree of transport. Figure 7a shows a gold grain with a delicate, subangular shape consisting of many small, rounded knobs joined together. The rounded, knobby texture is probably a nuggety product of abrasion and transport. The rounded protrusions provide sheltered spaces for accumulation of a coating of flakey hematite over parts of the grain that were protected from abrasion. This hematite could indicate that the grain may have been in contact with a sulphide crystal, or completely enclosed inside one.

Figure 7b shows a gold grain with a different habit. This grain appears to be either a composite of other grains joined by silicification, or a grain similar to that in Figure 7a but with less protrusions and a silicate coating over parts of the grain. This grain also exhibits a flaky hematitic coating that could be primary in nature or from a paleoplacer environment. Paleoplacers commonly contain a variety of heavy, stable minerals such as ilmenite, native metals and magnetite. Sulphides often find their way into paleoplacer environments as well, either as clasts or forming from later fluid migration. Stringers of pyrite are common in permeable rocks. Basal conglomerates are often some of the most permeable in strata of the Late Carboniferous. Basal lag units also commonly contain organic debris found at the bottoms of channels and stream beds. When buried, these organic particles produce methane under anaerobic conditions. Methane creates a reducing environment suitable for the deposition of sulphides invading strata in migrating solutions. The grain in Figure 7b also exhibits hints of a

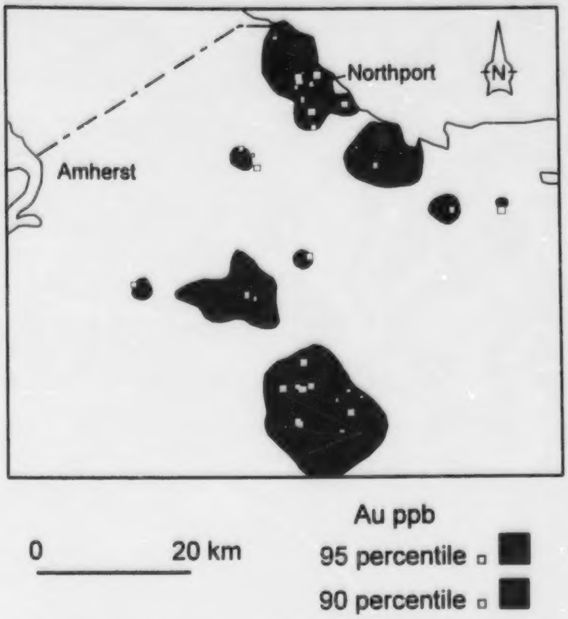


Figure 5. 90th (and greater) percentile gold anomalies of -230 mesh stream sediments for the Cumberland Basin, in the area around Northport, Nova Scotia (after Mills, 1989).

once wiry nature. One small bit of delicate wire protrudes from this grain on one corner. The grain has an overall subangular shape but exhibits nuggety charcteristics on most corners, not unlike the grain in Figure 7a.

Several parallels can be drawn between Northport and the Aboushagan area of southeastern New Brunswick (Fig. 8) where gold was discovered in a boulder of veined, silicified sandstone in 1996 by prospector Emilio Doiron. This boulder yielded 11.5 g/t gold (Johnson and MacLeod, 1998). This area was known to host native copper visible in the peat of modern bogs (Gussow, 1953). The area was subsequently investigated for base metals in the 1960s (Dome Exploration Canada Ltd.., 1964). Investigation has also focused on local structural features, such as fault scarps, in an attempt to find the source of these occurrences. Anomalous concentrations as high as 6.8 g/t Au have been found in samples of overburden along a local scarp (Mills, 1996). This scarp is interpreted to be a splay of the northeast-trending Dorchester Fault, a major structural feature in southern New Brunswick (Fig. 4).

The boulder at Aboushagan was investigated by Johnson and MacLeod (1998), who found that gold was enclosed in a quartz grain and, therefore, probably paleoplacer in origin. Structural features such as fault scarps and bedrock contacts are interpreted as good exploration targets as they offer suitable basement topographic depression for fluvial concentration of heavy elements in ancient, buried environments.

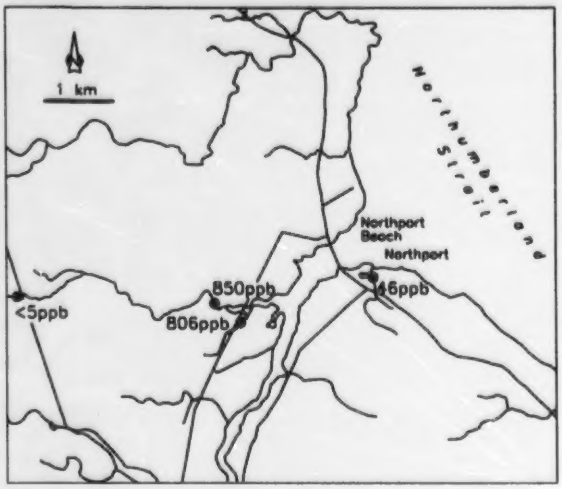


Figure 6. -230 mesh stream sediment gold anomaly levels for the area around Northport, Nova Scotia (after Mills, 1989).

Structural features present at Northport offer much of the same type of environment for deposition. Mineralized bogs have been documented in the Cumberland Basin (Feetham, 1996a and 1996b) and in the Cobequid Highlands as well (Smitheringale, 1928). Recently published vertical gradient aeromagnetic data (Geological Survey of Canada, 1994) reveal an anomalously low vertical gradient signature coincident with the unexplained stream sediment gold anomaly at Northport. This geophysical anomaly closely follows an inferred (buried) topographic depression (Fig. 9).

Conclusions

Paleoplacer gold occurrences in southeastern New Brunswick may be derived from a similar source as the Northport showing in Nova Scotia. It is conceivable that mineralization coincided with highland erosion and deposition in the Moncton Subbasin and Cumberland Basin. Additionally, paleoflow indicators in Nova Scotia suggest the Cobequid Highlands may have been a possible contributing source. It is also conceivable that gold present at the Northport anomaly could be formed from parental material derived from the Middle Devonian (and older) to Lower Carboniferous rocks of the

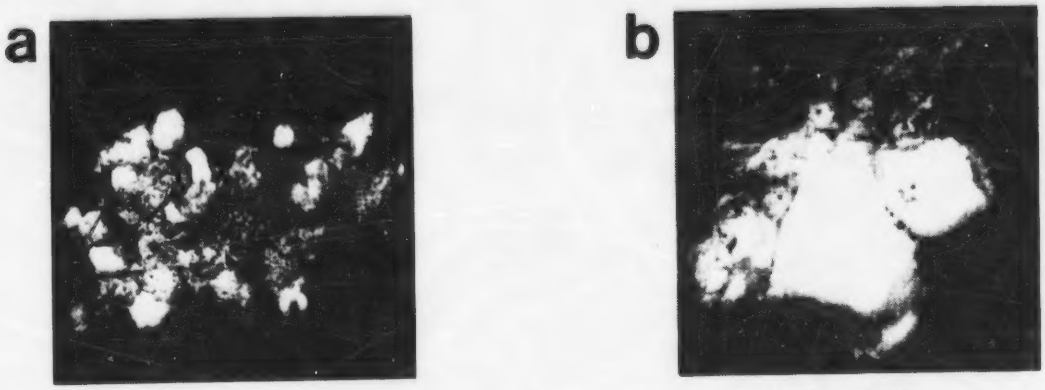


Figure 7. S.E.M. micrographs of gold grains taken from the beach at Northport, Nova Scotia.

Cobequid Highlands, which are known to host numerous, small gold occurrences. A placer deposit could form from distal material originally derived from the Cobequid Highlands by being re-concentrated in suitable environments along local paleotopographic sinks, such as contacts. This could help offer an explanation for the anomaly at Northport, as well as other small, unexplained gold anomalies in the Cumberland Basin.

Acknowledgments

The author wishes to thank Michael W. Milner for providing the panned concentrate from Northport beach from which the grains in Figure 7 were retrieved. Figures 1 and 8 were modified from images provided by Malcolm MacLeod of the New Brunswick Department of Natural Resources and Energy. Dr. Robert Ryan reviewed the manuscript.

References

Boyle, R. W. 1987: Gold: History and Genesis of Deposits; Society of Economic Geologists and Society of Economic Geologists Foundation; Van Nostrand Reinhold, New York, 676 p.

Dome Exploration Canada Ltd. 1964: Diamond-drilling, Upper Sackville, (NTS 21H/16W); New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division; Mineral Exploration Report of Work, Assessment File 470661.

Donohoe, H. V. and Wallace, P. W. 1982: Geological maps of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia; Nova Scotia Department of Mines and Energy, Maps 82-6 to 82-9, scale 1:50 000.

Feetham, M. 1996a: Bog iron, Wallace; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Mineral Occurrence Database Report 11E11-019, updated June 1996.

Feetham, M. 1996b: Shulie Mn occurrence; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Mineral Occurrence Database Report 21H10-001, updated October 1996.

Geological Survey of Canada 1994: Airborne Magnetometer Survey Vertical Gradient Images for 11E; Nova Scotia Department of Natural Resources, Digital Information Compilation, DP006.

Gibling, M. R., Calder, J. H., Ryan, R. J., van de Poll, W. and Yeo, G. 1991: Pennsylvanian and Permian paleoflow in Atlantic Canada; Canadian Journal of Earth Sciences, v. 28, p. 1157-1169.

Gussow, W. C. 1953: Carboniferous stratigraphy and structural geology of New Brunswick, Canada; American Association of Petroleum Geology Bulletin, v. 37, p. 1713-1816.

Johnson, S. C. and MacLeod, M. J. 1998: A note on the potential for paleoplacer gold in the Memramcook and Sackville areas and the relationship to Upper Carboniferous stratigraphy; *in* Current Research 1997; New Brunswick Department of Natural Resources and Energy, Mineral Resource Report MRR 98-4, p. 1-15.

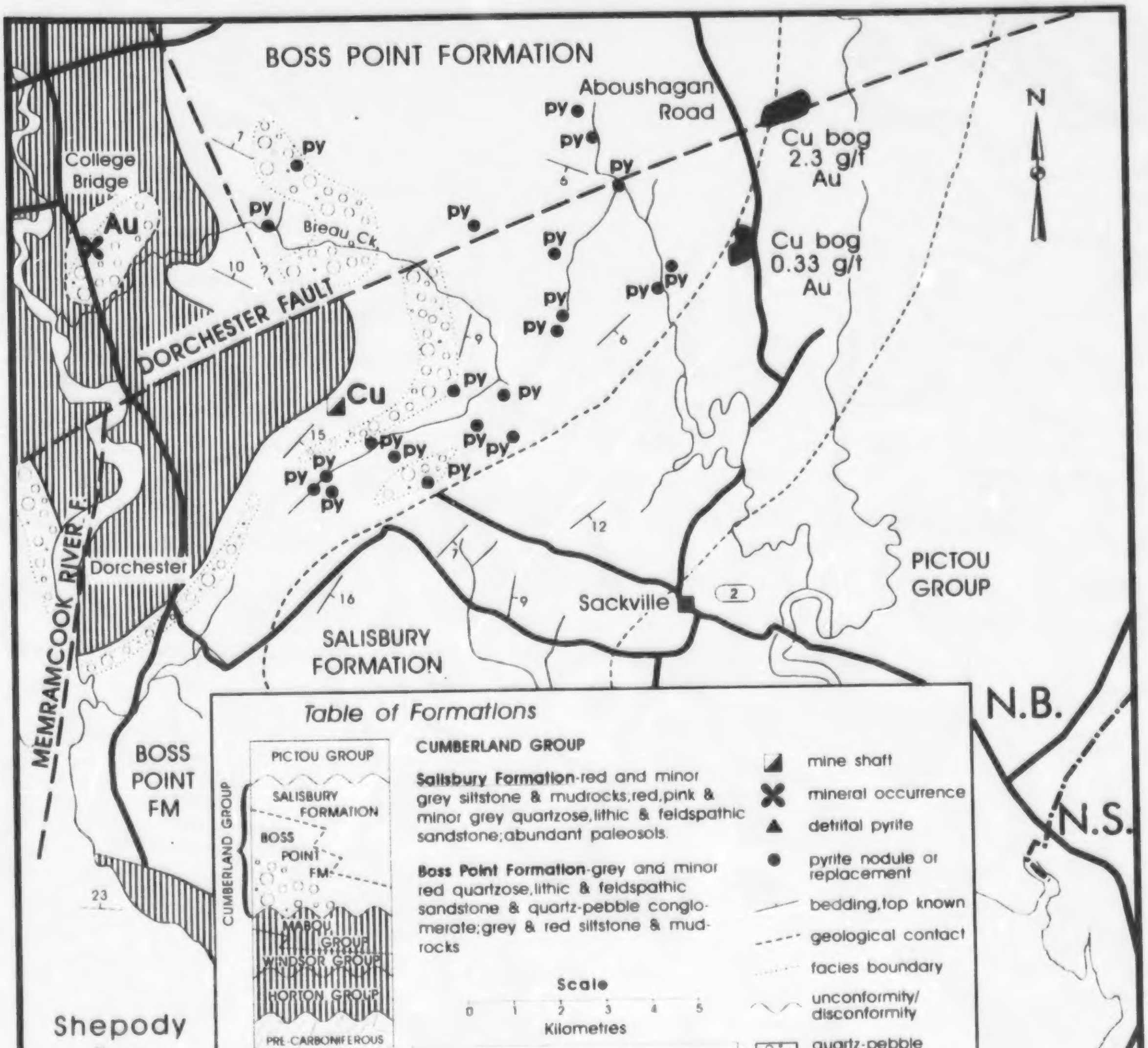

BOSS POINT FORMATION
Aboushagan Road
College Bridge
Au
py
Bieau Ck.
DORCHESTER FAULT
Cu
Cu bog 2.3 g/t Au
Cu bog 0.33 g/t Au
N
MEMRAMCOOK RIVER F.
Dorchester
Sackville
2
PICTOU GROUP
SALISBURY FORMATION
BOSS POINT FM
N.B.
N.S.
Shepody Bay
Table of Formations
PICTOU GROUP
SALISBURY FORMATION
BOSS POINT FM
CUMBERLAND GROUP
MABOU GROUP
WINDSOR GROUP
HORTON GROUP
PRE-CARBONIFEROUS
CUMBERLAND GROUP
Salisbury Formation-red and minor grey siltstone & mudrocks;red,pink & minor grey quartzose,lithic & feldspathic sandstone;abundant paleosols.
Boss Point Formation-grey and minor red quartzose,lithic & feldspathic sandstone & quartz-pebble conglomerate;grey & red siltstone & mudrocks
Scale
0 1 2 3 4 5
Kilometres
modified from Johnson & MacLeod, 1997.
mine shaft
mineral occurrence
detrital pyrite
pyrite nodule or replacement
bedding,top known
geological contact
facies boundary
unconformity/ disconformity
quartz-pebble conglomerate
7
10
6
9
15
12
16
23

Figure 8. Proximity of Aboushagan gold anomaly and cupriferous bogs described by Gussow (1953) to the Dorchester Fault, southern New Brunswick (after Johnson and MacLeod, 1998).

Leckie, D. A., VanBeselaere, N. A., El-Dein, S. S., McIntyre, D. I. and Swanson, F. 1998: Gold potential and paleogeography of Mannville Sediments (Lower Cretaceous) of north central Saskatchewan: a new exploration Concept; Geoscience Canada, v. 25, no. 3, p. 115-127.

Miller, C. K. 1987: The Maritime gold play, Scotia Prime Resources Ltd., executive summary; Nova Scotia Department of Natural Resources, Miscellaneous Report MR-M-133, 4 p.

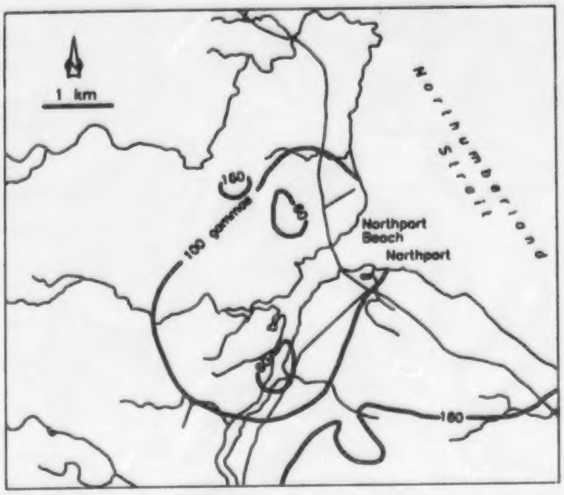


Figure 9. Vertical gradient aeromagnetic anomaly depression in the vicinity of the Northport gold anomaly. This anomaly for the Cumberland, Basin, in the area around Northport, Nova Scotia could be interpreted as a basement depression (after Geological Survey of Canada, 1994).

Mills, R. F. 1989: Geochemical analyses of bulk stream sediment samples from northern Nova Scotia (Parts of NTS sheets 11E; 11F; 11G; 11J; 11K and 21H); Nova Scotia Department of Natural Resources, Open File 89-007, 368 p.

Mills, R. F. 1996: Report on prospecting, staking, and till and stream sediment geochemistry on two sets of contiguous claim blocks in the vicinity of the Aboushagan gold anomaly, Westmoreland County, New Brunswick; Briar Island Resources, Interim Report, September 1996, 26 p.

Northcote, K., DeMont, G. J. and Armitage, A. 1989: Selected mineral occurrences in the Cobequid area; Nova Scotia Department of Natural Resources, Open File Report 89-005.

Ryan R. J., Boehner R. C. and Deal, A. 1990: Cumberland Basin geology map, Oxford and Pugwash, Cumberland County; Nova Scotia Department of Natural Resources, Map 90-13, scale 1:50 000.

Ryan R. J. and Boehner R. C. 1994: Geology of the Cumberland Basin, Cumberland, Colchester and Pictou Counties, Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branch, Memoir 10, 222 p.

Smitheringale, W. V. 1928: The manganese occurrences of the Maritime Provinces; Massachusetts Institute of Technology, Ph.D. Thesis; Nova Scotia Department of Natural Resources, Miscellaneous Report MR-S-155, 121 p.

Progress report on geological mapping in the Parrsborro area (NTS 21H/08), Cumberland County, Nova Scotia

R. D. Naylor, K. Adams[1], J. H. Calder, T. A. Costain and B. A. McCarthy

Introduction

Geological mapping of the Parrsboro area forms part of a Nova Scotia Department of Natural Resources (NSDNR) project to map Carboniferous and Mesozoic strata adjacent to the south side of the Cobequid Highlands (see Naylor and Kennedy, 1997). The purpose of this project is to create geological maps that provide a more detailed basis for exploration programs and land-use planning. Mapping is undertaken at a 1:10 000 scale using digital base maps provided by the Nova Scotia Geomatics Centre. FieldLog® and AutoCad® are used to add geological data to the maps.

The spectacular coastal sections of Carboniferous and Mesozoic strata near Parrsboro have long been known as important sites for fossil and mineral collecting. Mr. Eldon George, a lifelong resident of the Parrsborro area, has been garnering attention to the area for over 50 years with his fossil discoveries. In 1984 fossils of some of the earliest (200 Ma) mammal-like creatures known to exist were discovered near Parrsborro (Olsen *et al.*,1987). Subsequently, five partial skeletons of the oldest dinosaur fossils in Canada were found. With these discoveries, interest in the geology of the Parrsboro area grew, culminating in the opening of the Fundy Geological Museum in 1993.

Visitors to the Fundy Geological Museum often ask if there is a geological map that can help guide them to fossil- and mineral-collecting sites in the area. With the assistance of Mr. George and staff of the Fundy Geological Museum, NSDNR has expanded our project mandate in the Parrsboro area to include creation of a geological map that is suitable for use by the general public. This map will be produced in addition to the standard 1:10 000 geological map. Such maps can contribute to community-based economic development of fossil and mineral sites.

Progress

During the summer of 1998, work in the Parrsboro area focused on mapping all the Carboniferous coastal sections from Cape Sharp to McLaughlin Bluff. The units examined were (oldest to youngest) marine evaporites and nearshore redbeds of the Windsor Group, succeeded by nearshore marine to lacustrine redbeds and grey beds of the Mabou Group, and grey beds and redbeds of the "coal measures" assigned to the Cumberland Group.

All these units showed varying degrees of deformation; however, it is clear that the Mabou and Windsor groups are significantly more deformed than the Cumberland Group. There are at least two locations along the coast where the Cumberland Group appears to sit with angular unconformity on the Mabou Group. Although there is fairly good exposure at these locations, it is still possible that the units are separated by a fault rather than an unconformity.

In addition to mapping coastal sections, some work was completed inland to better determine regional contact relationships between units. Most of this work was restricted to outcrops adjacent to primary and secondary roads.

An important part of this summer's work was to document the locations of fossil sites in the sections. Eldon George provided invaluable assistance with this work and generously shared his thorough knowledge of the Parrsboro area.

A draft, full-colour museum version of the Parrsboro map sheet was prepared and presented at the Mining Matters '98 conference in Halifax, and subsequently at a testimonal dinner held in honour of Mr. George in Parrsboro. The map illustrates the basic geology of the area complete with fossil sites and locations where the

---

[1] Fundy Geological Museum, Two Islands Road, Parrsboro, Nova Scotia B0M 1S0

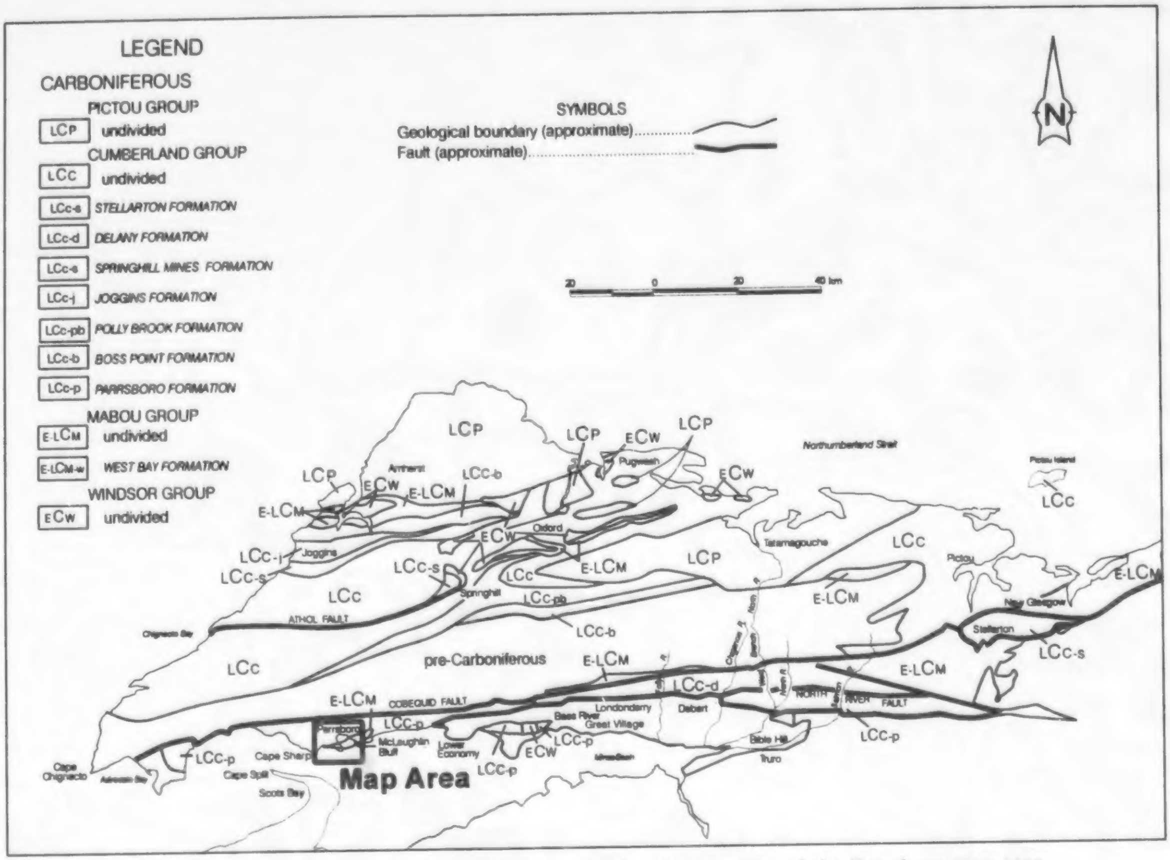

LEGEND
CARBONIFEROUS
PICTOU GROUP
LCP undivided
CUMBERLAND GROUP
LCc undivided
LCc-s STELLARTON FORMATION
LCc-d DELANY FORMATION
LCc-s SPRINGHILL MINES FORMATION
LCc-j JOGGINS FORMATION
LCc-pb POLLY BROOK FORMATION
LCc-b BOSS POINT FORMATION
LCc-p PARRSBORO FORMATION
MABOU GROUP
E-LCM undivided
E-LCM-w WEST BAY FORMATION
WINDSOR GROUP
ECw undivided
SYMBOLS
Geological boundary (approximate)
Fault (approximate)
N
20 0 20 40 km
Northumberland Strait
Pictou Island
Amherst
Pugwash
Oxford
Joggins
Springhill
Tatamagouche
Pictou
New Glasgow
Stellarton
Chignecto Bay
ATHOL FAULT
pre-Carboniferous
COBEQUID FAULT
NORTH RIVER FAULT
Londonderry
Bass River
Great Village
Debert
Bible Hill
Truro
Parrsboro
McLaughlin Bluff
Lower Economy
Cape Sharp
Cape Split
Scots Bay
Cape Chignecto
Advocate Bay
Map Area

Figure 1. Simplified geological map of northern Nova Scotia showing location of the Parrsboro map area.

coast can be easily accessed. Marginal notes describe the general geological history of the area, and icons of the various fossils are used to link the margin notes to fossil sites shown on the map.

Future Work

Mapping of the Parrsboro area should be completed during the next field season. A preliminary version of the museum visitors map will be available in July 1999. The intention is to provide 25-50 visitors to the museum with copies of the map for their use and comments. Based on the comments received the map will be modified and a final version should be available for the 2000 tourist season.

The standard geological map of the Parrsboro area should be available in late 1999 or early in the year 2000. Standard geological maps of the Carboniferous and Mesozoic strata in the Londonderry, Bass River, and Great Village areas are planned to be completed during 1999.

References

Naylor, R. D. and Kennedy, C. M. 1997: Stratigraphy and sedimentology of the Late Carboniferous Parrsboro Formation; *in* Minerals and Energy Branch, Report of Activities 1997, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Report 1998-1, p. 115-126.

Olsen, P. E., Shubin, N. H. and Anders, M. H. 1987: New Early Jurassic tetrapod assemblages constrain Triassic-Jurassic tetrapod extinction event; Science, v. 28, p. 1025-1029.

Fluvio-estuarine sedimentation in the Late Carboniferous Malagash Formation of Nova Scotia, Canada

R. D. Naylor, A. W. Archer[1], F. W. Chandler[2] and P. W. Fralick[3]

Abstract

The Westphalian C-D Malagash Formation of Nova Scotia is dominated by thick, fluvial sandstones and redbeds containing calcrete-bearing vertisols. These volumetrically dominant facies, which constitute approximately 85% of the Malagash Formation, suggest braided fluvial deposition alternated with extensive periods of floodplain development. The Malagash Formation, unlike its stratigraphic equivalents, lacks economic deposits of coal and has been considered to be an upland equivalent to laterally correlative coal measures that were deposited basinward. Despite the apparently upland character of the dominant facies, 12% of the Malagash Formation comprises heterolithic facies containing fine-scale laminations and agglutinated foraminifera indicative of estuarine and tidal influences during sedimentation.

The Westphalian C-D was a period of high frequency, high amplitude glacio-eustatic flux and the resultant base level changes appear to have influenced the facies-stacking patterns. The calcrete vertisols suggest a strongly seasonal, potentially monsoonal, paleoclimatic overprint at paleolatitudes that were approximately equatorial.

Introduction

Purpose of Investigation

The Late Carboniferous strata of Atlantic Canada traditionally have been ascribed a nonmarine origin based on the absence of marine fossils and general similarities to fluvial and lacustrine deposits. Earlier workers used the characteristics of the Late Carboniferous coals to suggest that some were deposited within proximal marine (paralic) settings (Haquebard *et al.*, 1967; Haquebard and Donaldson, 1969). Direct evidence of marine influenced deposition was not noted by these authors.

Discovery of fossil protozoans (agglutinated foraminifera) in the Sydney Coalfield (Fig. 1) (Thibaudeau and Medioli, 1986) initially provided evidence for Late Carboniferous marine influences in Atlantic Canada. These organisms closely resemble those found in modern estuaries and saline marshes. Subsequently, cyclothems inferred to have been controlled by base-level (eustatic) flux, that contained similar foraminiferal assemblages (Wightman *et al.*, 1993), were delineated within the Sydney Coalfield (Bird, 1987; Gibling and Bird, 1994). Detailed analysis of the sedimentology, stratigraphy and agglutinated foraminifera of an individual cyclothem (Gibling and Wightman, 1994) allowed the differentiation of coastal plain, paleovalley-fill, and alluvial-plain deposits. Recently, similar foraminiferal assemblages have been documented from Late Carboniferous coal-bearing strata of the Gulf of St. Lawrence Basin (Fig. 1) (Wightman *et al.*, 1994a). Calder (1998) asserted that some of the Late Carboniferous fossil fauna of Atlantic Canada, that has traditionally been described as nonmarine, be interpreted to have a nearshore marine affinity. Calder (1998) also pointed out that paleogeographic, paleoflow and faunal 'trends' suggest that a Mid-Euramerican Sea exsisted between the Maritimes and Europe throughout the Carboniferous.

Until now, the search for evidence of marine influence within the Late Carboniferous strata of Atlantic Canada has been confined to the coal measures. This study focuses on the Malagash Formation; a largely non coal-bearing succession of sandstone and red mudrock, which is age equivalent to the Westphalian C-D coal measures. The purpose of our research is to look for evidence that may suggest marine influence, inland from the coal measures, in what has traditionally been considered a fluvial dominated nonmarine setting.

---

[1] Department of Geology, Kansas State University, Manhattan, Kansas 66506, U.S.A.
[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A OE8
[3] Department of Geology, Lakehead University, Thunder Bay, Ontario P7B 5E1

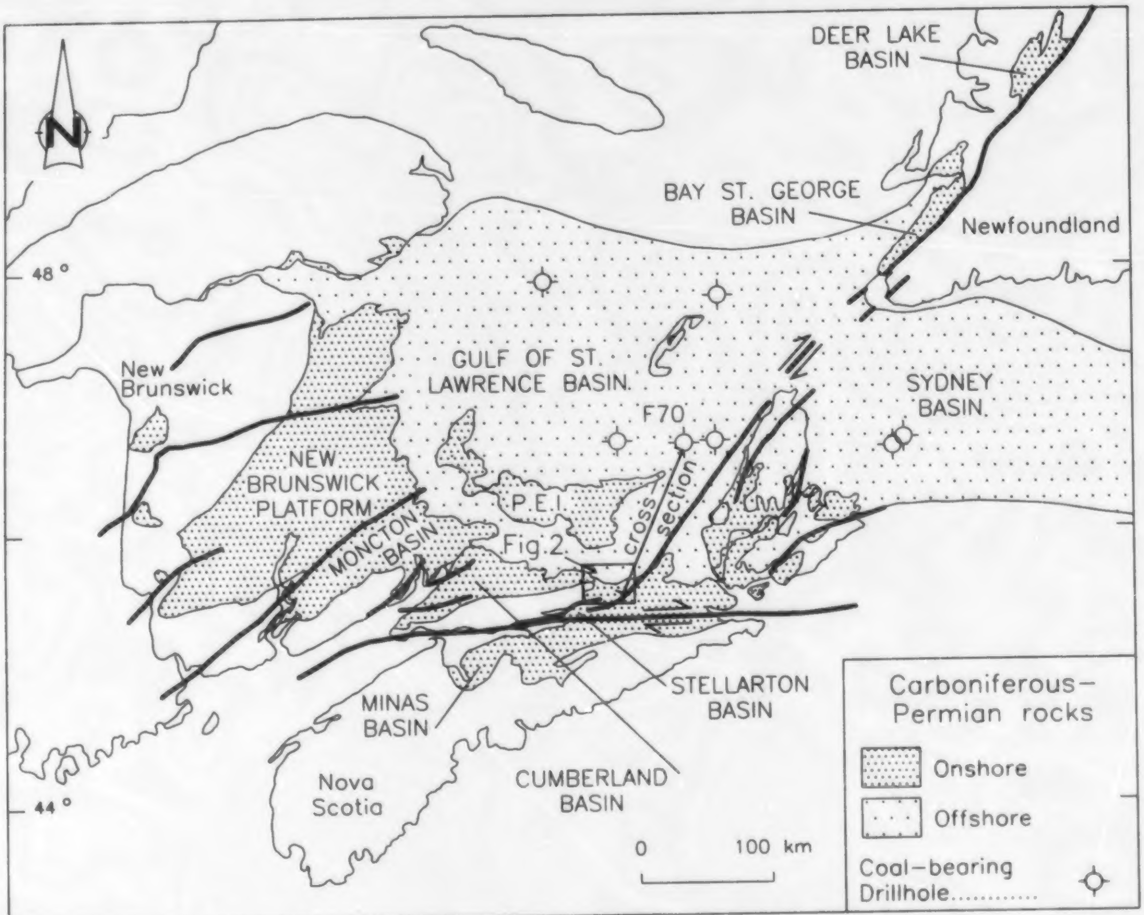

N
DEER LAKE BASIN
BAY ST. GEORGE BASIN
Newfoundland
48°
New Brunswick
GULF OF ST. LAWRENCE BASIN
SYDNEY BASIN
F70
NEW BRUNSWICK PLATFORM
MONCTON BASIN
P.E.I.
cross section
Fig. 2
STELLARTON BASIN
MINAS BASIN
Nova Scotia
CUMBERLAND BASIN
44°
0
100 km
Carboniferous–Permian rocks
Onshore
Offshore
Coal–bearing Drillhole............

Figure 1. Distribution of Carboniferous basins in Atlantic Canada showing location of study area and cross-section illustrated in Figures 2 and 4 respectively.

General Geological Setting

Sediment deposition and concurrent development of mires was widespread in Atlantic Canada during the Westphalian C-D. Much of the detritus was deposited in the regionally extensive Sydney and Gulf of St. Lawrence basins (Fig. 1); however, unusually thick (2600 m) Westphalian successions also accumulated in small (120 km^2), rapidly subsiding basins within major strike slip fault systems, such as the Stellarton Basin (Figs. 1, 2) (Fralick and Schenk, 1981; Yeo and Ruixiang, 1987; Naylor *et al.*, 1992). Sediment, which may have been sourced as far away as the Central Appalachians (Gibling *et al.*, 1992), was carried into the depositional basins by northeastward flowing rivers. Erosion of local uplifts also provided a source of sediment as evidenced by onlap of proximal portions of alluvial fans onto basement (Fralick and Schenk, 1981).

The study area (Fig. 2) is contained within the Gulf of St. Lawrence Basin, a large (46 620 km^2), predominantly submerged basin that contains an average of 1000 m of Westphalian C-D strata (Haquebard, 1986; T. A. Rehill, personal communication, 1995). Westphalian C-D coals are well developed in central, northern and eastern areas of the basin (Haquebard, 1986); however, in the southern part of the basin, which includes the study area (Fig. 2), the Malagash Formation contains only rare, thin (<0.3 m), impure coals.

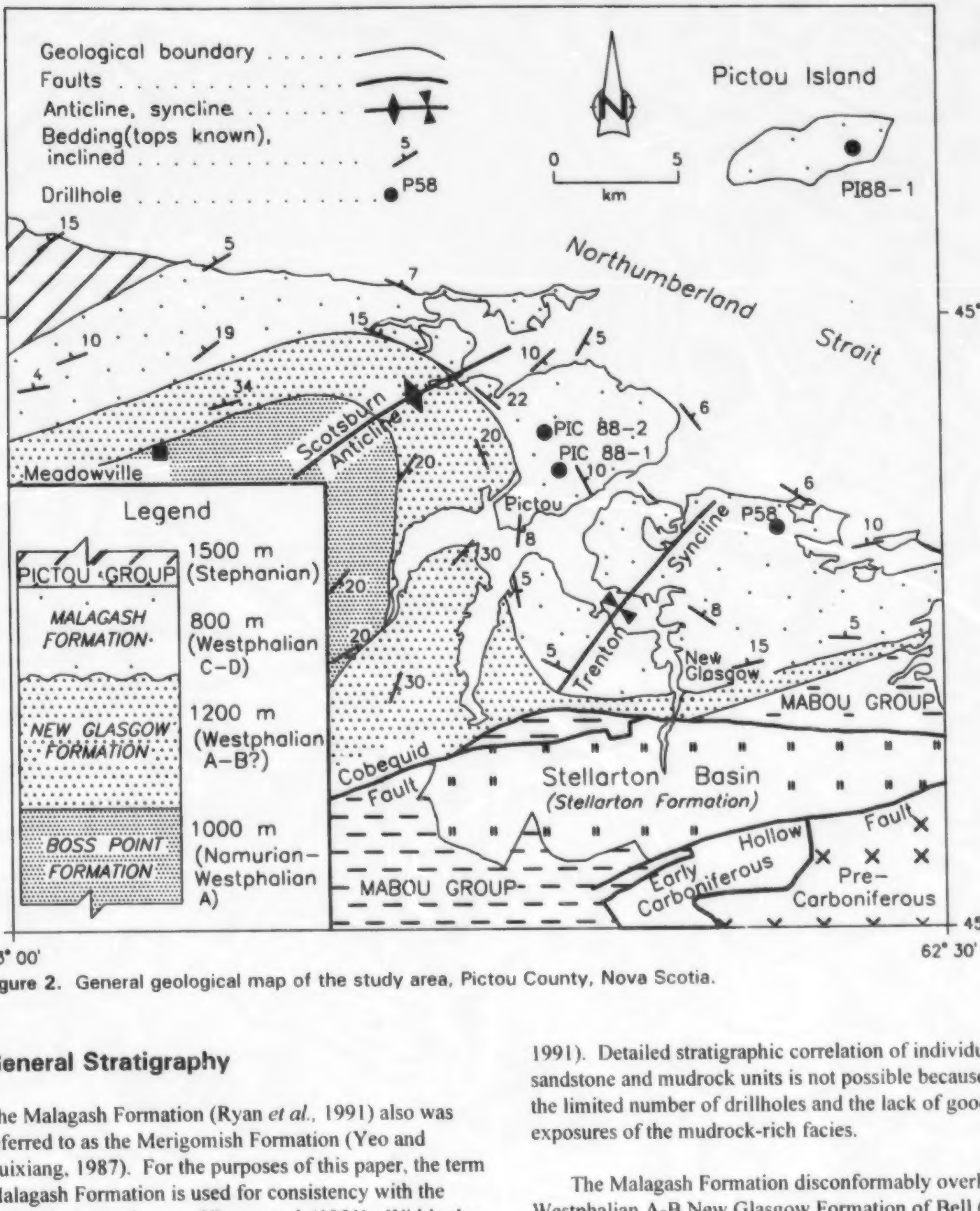

Geological boundary
Faults
Anticline, syncline
Bedding(tops known), inclined
Drillhole
P58
km
0
5
Pictou Island
PI88-1
Northumberland Strait
45° 45'
45° 30'
63° 00'
62° 30'
Meadowville
Scotsburn Anticline
PIC 88-2
PIC 88-1
Pictou
Trenton Syncline
New Glasgow
MABOU GROUP
Cobequid Fault
Stellarton Basin
(Stellarton Formation)
Hollow Fault
Early Carboniferous
Pre-Carboniferous
Legend
PICTOU GROUP
1500 m (Stephanian)
MALAGASH FORMATION
800 m (Westphalian C-D)
NEW GLASGOW FORMATION
1200 m (Westphalian A-B?)
BOSS POINT FORMATION
1000 m (Namurian-Westphalian A)

Figure 2. General geological map of the study area, Pictou County, Nova Scotia.

General Stratigraphy

The Malagash Formation (Ryan *et al.*, 1991) also was referred to as the Merigomish Formation (Yeo and Ruixiang, 1987). For the purposes of this paper, the term Malagash Formation is used for consistency with the regional nomenclature of Ryan *et al.* (1991). Within the study area, the Malagash Formation is 800 m thick and consists of units of grey sandstone, red mudrock, grey mudrock, and rare, thin, impure coals (Fig. 3). In the southernmost part of the study area, the base of the Malagash also includes black shales/oil shales and a stromatolitic limestone (Yeo and Ruixiang, 1987; Palmer, 1991). Detailed stratigraphic correlation of individual sandstone and mudrock units is not possible because of the limited number of drillholes and the lack of good exposures of the mudrock-rich facies.

The Malagash Formation disconformably overlies the Westphalian A-B New Glasgow Formation of Bell (1940) (alluvial fan deposits) and grey sandstone dominated Westphalian A-B strata that are, here, informally assigned to the Cumberland Group (Fig. 4). Northeast of the Trenton Syncline, down paleoslope, the Malagash Formation interfingers with the predominantly grey Westphalian C-D coal measures of the Inverness

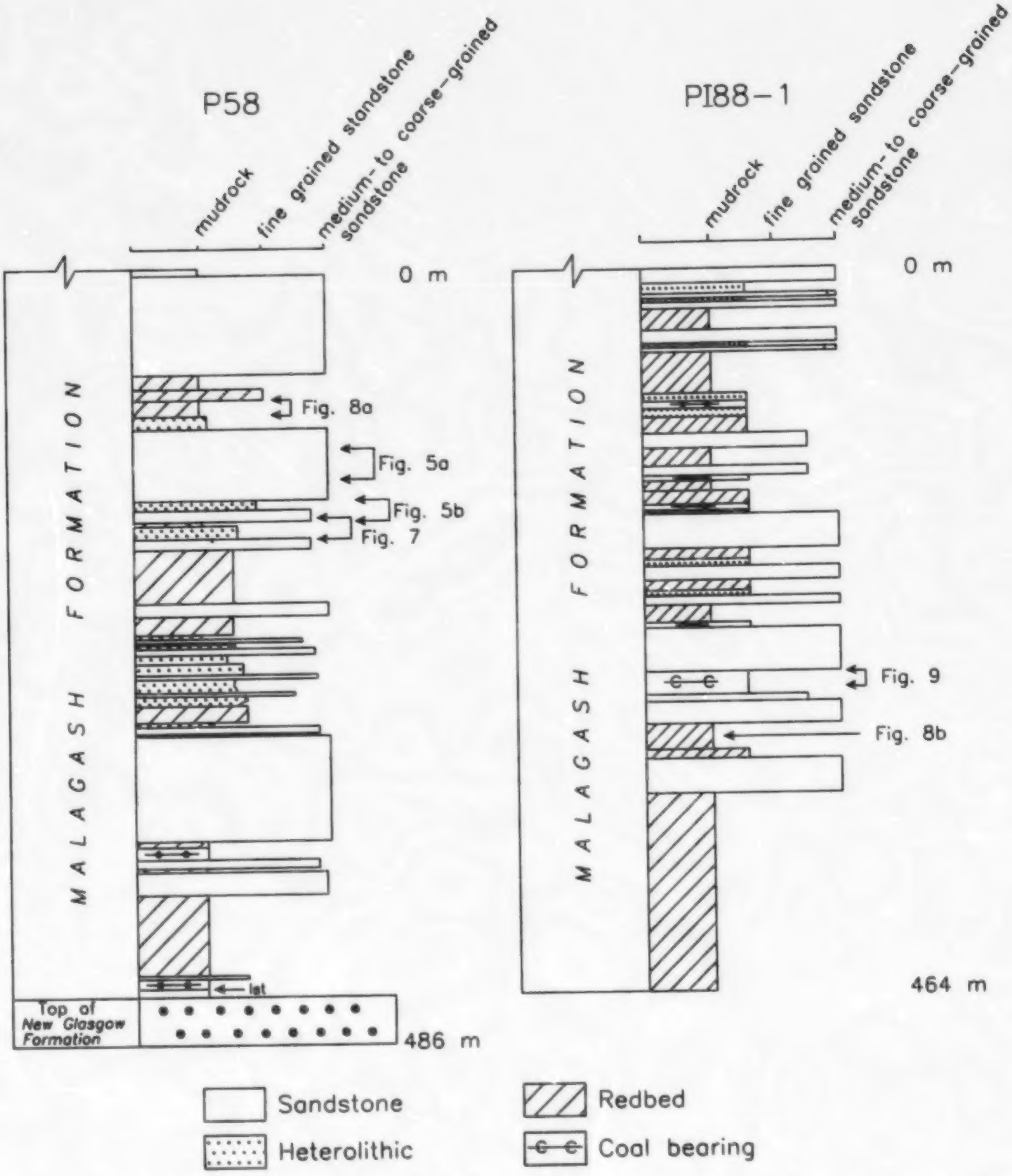

P58
PI88-1
mudrock
fine grained standstone
medium- to coarse-grained sandstone
mudrock
fine grained sandstone
medium- to coarse-grained sandstone
0 m
0 m
MALAGASH FORMATION
MALAGASH FORMATION
Fig. 8a
Fig. 5a
Fig. 5b
Fig. 7
Fig. 9
Fig. 8b
lst
Top of New Glasgow Formation
486 m
464 m
Sandstone
Heterolithic
Redbed
Coal bearing

Figure 3. Graphic logs of drillholes P58 and PI88-1 illustrating the vertical arrangement of facies associations within the Malagash Formation and the locations of detailed lithologic profiles. See Figure 2 for drillhole locations.

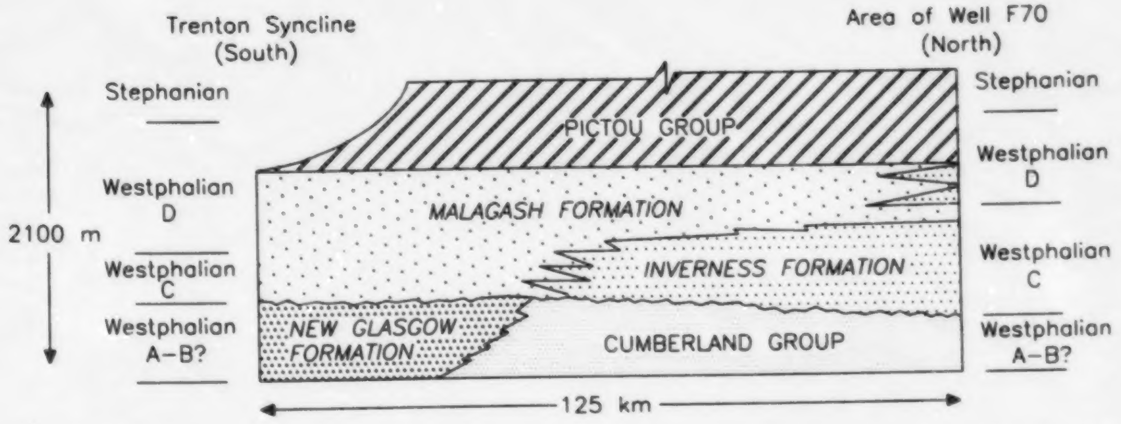


Figure 4. Cross-section illustrating down paleoslope change in Westphalian stratigraphy from the study area to the central eastern Gulf of St. Lawrence Basin. See Figure 1 for location of cross-section.

Formation. West of the study area, along depositional strike, the Malagash Formation thins (100-400 m), but is still traceable to at least the area of the Moncton Basin in New Brunswick (Fig. 1; about 150 km) (Ryan *et al.*, 1991). The Malagash Formation may be equivalent to the Richibucto Formation and part of the Salisbury Formation in New Brunswick (S. Johnson, personal communication, 1995).

The Stellarton Basin/Pictou Coalfield lies immediately south of the study area, across the strike-slip Cobequid Fault system (Fig. 2). This basin contains the Stellarton Formation, a 2600 m thick, grey, coal-bearing lacustrine succession that is age equivalent to the Malagash Formation (Yeo and Ruixiang, 1987; Naylor *et al.*, 1989).

Description of Facies Associations

All outcrops and drillcores of the Malagash Formation were examined within the study area. Cores were available from four drillholes PIC 88-1, PIC 88-2, P58 and PI88-1 (Fig. 2). All of these holes were continuously cored. Drillcores proved particularly useful for describing the sedimentology of mudrock dominated units and for recognizing large scale vertical arrangement of facies. Drillholes P58 and PI88-1 represent the most complete sections in the study area (Figs. 2, 3).

Within the study area the Malagash Formation can be subdivided into the following four facies associations: (1) sandstone, (2) heterolithic, (3) redbed, and (4) coal bearing. The most common vertical arrangement of these facies associations comprises sandstone facies overlain by heterolithic facies that grade upward into redbeds (Fig. 3). Rocks of the coal-bearing association are uncommon. Information on each facies association is presented in detail in the following sections.

Sandstone Association

The sandstone association comprises 53% of the Malagash Formation in the study area (Fig. 3). This association is composed of lithic-feldspathic grit to quartzose sandstone that contains fresh detrital biotite, chlorite, muscovite, and fresh to altered plagioclase and microcline grains. Quartz grains are very angular and do not show embayments or hematite-filled fractures.

Coarser facies are pale grey and finer facies are pale green grey. Intraformational conglomerates are common and comprise grey mudrock, calcrete clasts and occasional extraformational quartz and granitic pebbles (Figs. 5a, 6a). Red mudrock intraclasts are conspicuously absent except for very rare occurrences adjacent to some contacts with redbeds. Carbonized to coaly plant material is locally common and ranges in size from transported logs up to 5 m in length to finely macerated debris that defines ripple and planar laminae. Plant fragments are occasionally pyritized (Figs. 5a, b).

The sandstones of this association are 1-60 m thick and can be subdivided into thick and thin units. Thick (14-60 m) sandstones (Fig. 5a) are multistoried and generally lack well-developed vertical changes in the scale of sedimentary structures (Yeo and Ruixiang, 1987;

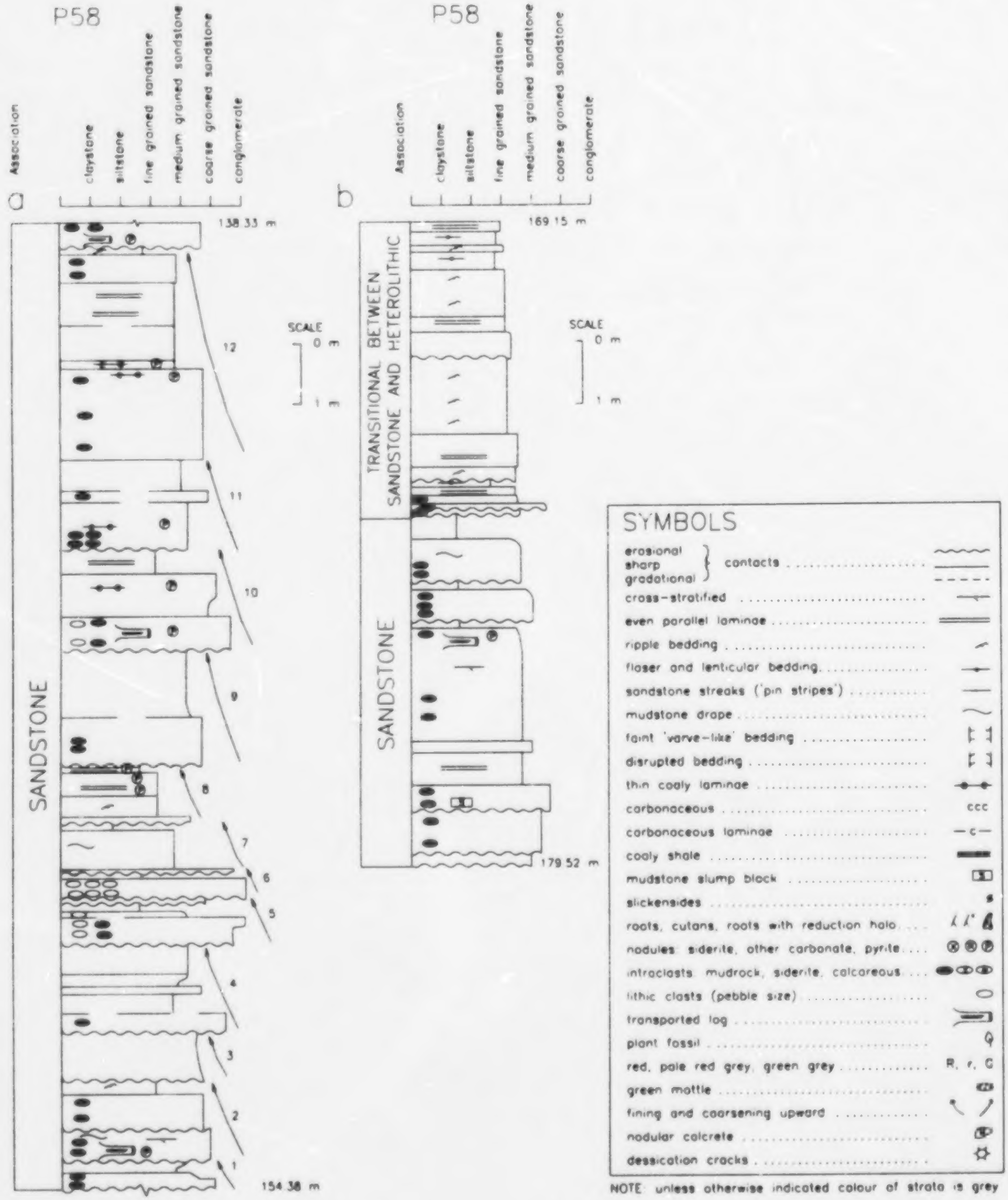

P58
a
Association
claystone
siltstone
fine grained sandstone
medium grained sandstone
coarse grained sandstone
conglomerate
138.33 m
154.38 m
SANDSTONE
1
2
3
4
5
6
7
8
9
10
11
12
SCALE
0 m
1 m
P58
b
Association
claystone
siltstone
fine grained sandstone
medium grained sandstone
coarse grained sandstone
conglomerate
169.15 m
179.52 m
TRANSITIONAL BETWEEN SANDSTONE AND HETEROLITHIC
SANDSTONE
SCALE
0 m
1 m
SYMBOLS
erosional
sharp
gradational
contacts
cross-stratified
even parallel laminae
ripple bedding
flaser and lenticular bedding
sandstone streaks ('pin stripes')
mudstone drape
faint 'varve-like' bedding
disrupted bedding
thin coaly laminae
carbonaceous
ccc
carbonaceous laminae
—c—
coaly shale
mudstone slump block
slickensides
roots, cutans, roots with reduction halo
nodules: siderite, other carbonate, pyrite
intraclasts: mudrock, siderite, calcareous
lithic clasts (pebble size)
transported log
plant fossil
red, pale red grey, green grey
R, r, G
green mottle
fining and coarsening upward
nodular calcrete
dessication cracks
NOTE: unless otherwise indicated colour of strata is grey

Figure 5. Detailed profiles illustrating the sedimentology of the sandstone facies association. For locations see Figure 3. (a) Thick multistoried sandstones. (b) Thin sandstone unit overlain by a sandstone that is transitional with the heterolithic facies association.

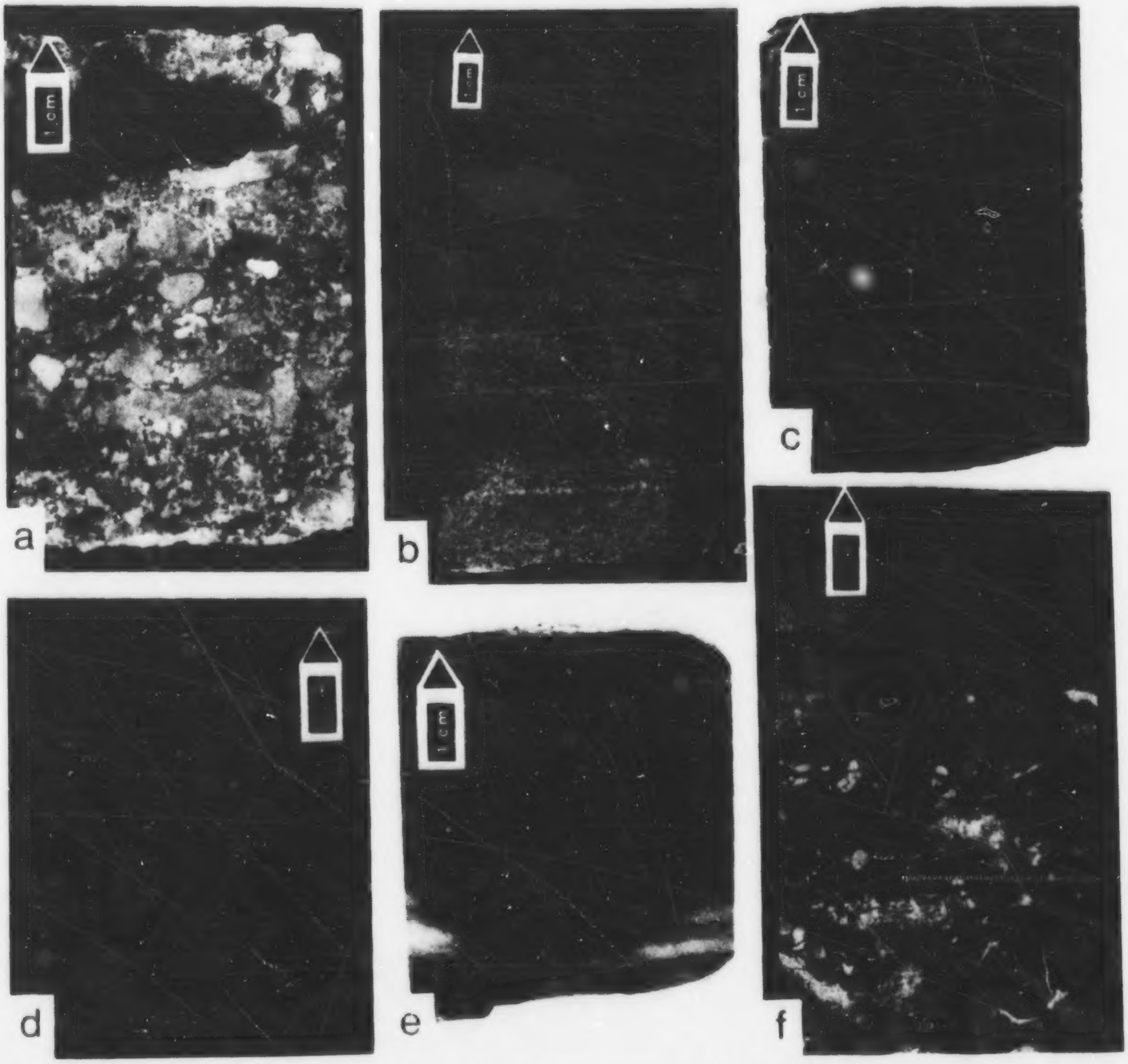


Figure 6. Photographs of typical lithologies from various facies associations. (a) Intraformational lag (sandstone association). (b) Thin mudstone drapes at a transition between the sandstone and heterolithic facies associations. (c) Flaser lenticular and streaked bedding in the heterolithic facies. See Figure 7 for location. (d) Streaked bedding in the heterolithic facies. See Figure 7 for location. (e) 'Varve-like' bedding within mudrocks (redbed association). See Figure 8 for location. (f) Nodular calcrete overlain by mottled green-grey mudrock. See Figure 8 for location.

Palmer, 1991; Ryan and Boehner, 1994). Individual storeys are 0.70-10 m thick, commonly fine-upward and are usually separated by intraformational conglomerates or pebbly sandstone layers (Fig. 5a). In outcrop, large scale trough cross-stratification is the predominant bedform; planar cross-stratification and ripple bedding are rare. Grain size variation and smaller scale structures, defined by carbonaceous or coaly laminae, can be observed in cores (Fig. 5a). Cored intervals that comprise larger scale crossbeds are more difficult to recognize because they usually appear massive. Millimetre scale mudstone drapes occur within some thick sandstone units (Figs. 5a, 6b). Thin (2-10 cm) mudrock interbeds are rare and most commonly cap an individual storey. Paleoflow measurements within thick multistoried sandstones indicate a strongly developed northward transport direction (Yeo and Ruixiang, 1987).

Thin sandstones can be single or multistoried (Fig. 5b), and can fine upward or show no overall vertical change in grain size. Grey, intraformational mudclasts are common and grey mudrock slump blocks were noted near the base of some beds. Millimetre scale mudstone drapes are rare. In core, the thin sandstone units generally appear massive, however large scale cross-stratification is locally delineated by faint carbonaceous laminae and subtle grain size changes. Thin mudrock interbeds (2-30 cm) are developed locally. The thin sandstones of this association can be locally transitional in character to the heterolithic facies association (Fig. 5b). These transitional units are predominantly fine grained sandstone with ripple and flaser bedding much more common. Paleoflow measurements were not obtained for thin sandstone units because of a general lack of outcrop.

It is not possible to convincingly correlate individual sandstone bodies of this association between drillholes P58 and PI88-1 (Figs. 2, 3). However, we were able to easily trace both thick and thin sandstone bodies for 920 m between drillholes PIC 88-1 and PIC 88-2. Although some of the sandstones showed a 30% change in thickness between these holes , individual sandstones as thin as 5 m were always laterally continuous.

Both the thick and thin sandstone units are most commonly overlain by heterolithic facies (Fig. 3). The lower contacts between the sandstone association and other facies associations are always erosional. Upper contacts with other facies associations are generally sharp (Figs. 6b, 7).

Heterolithic Facies Association

The heterolithic facies association accounts for only 12% of the Malagash Formation strata. Typically this association is 0.4-8.0 m thick (3.0 m average thickness) and abruptly overlies the sandstone association (Figs. 6b, 7). The transition of underlying sandstones to overlying heterolithic facies is commonly sharp and usually marked by a thin interval of well developed mud drapes (Fig 6b). The heterolithic facies generally comprises grey siltstone with pale grey lenticular and even parallel ('pin stripe') sandstone laminae (Fig. 6c, d). Interbeds (5-30 cm thick) of grey ripple-bedded or massive, fine- to medium-grained sandstone occur in the heterolithic facies. Commonly, the massive beds are overlain gradationally by unidirectional rippled beds. Sedimentary structures are usually well preserved except near contacts with redbeds. These contacts are characterized by root bioturbation and pedogenic overprinting. Plant fossils are rare to absent in the heterolithic facies association.

Three samples of the heterolithic facies were disaggregated and examined for microfossils. One sample contained uncoiled, agglutinated foraminifera assigned to the genus *Ammotium* (Wightman, 1995). The other two samples contained no specimens that could be positively identified as agglutinated foraminifera.

Redbed Association

The redbed association comprises 31% of the Malagash Formation in the study area. This association consists of 2-42 m thick intervals (Fig. 3) of red mudrock with subordinate red and grey fine- and medium-grained sandstone and rare green-grey to black mudrock. Mudrocks are usually poorly stratified with beds disrupted by roots, carbonate nodules and pedoturbation. Occasional bedding, preserved within mudrocks, consists of either 1 mm to 2 cm thick 'varve-like' siltstone-claystone couplets (Fig. 6e) or 'pin stripes' and lenticular laminae of pale grey sandstone. Sandstones generally exhibit better preservation of bedding than mudrocks. Silty sandstones are often rhythmically layered with pale red-grey, fine grained sandstone beds (5-10 cm thick) alternating with red silty-claystone beds (1-2 cm thick). Fine- to medium-grained sandstones are massive, trough cross-stratified or ripple bedded and contain rare intraformational clasts.

Sequences that coarsen upward are common throughout the redbed association (Fig. 8a). Typically these sequences are 0.5-3.0 m thick and consist of claystone coarsening upward to silty sandstone or thin (0.10-1.7 m), massive to ripple bedded, fine- to medium-grained sandstone. Thick (5-12 m), medium- and fine-grained sandstones are rare and comprise fining upward units that are trough cross-stratified near the base and ripple bedded toward the top.

Stacked paleosol profiles, that locally appear superimposed, are common throughout the Malagash redbeds (Chandler, 1995) (Fig. 8a, b). Individual paleosol profiles are up to 3.0 m thick, rich in smectite and exhibit varied stages of development. The simplest profiles contain root traces, rare carbonized roots, green mottles (in layers or around roots), poorly preserved plant material and pedogenic slickensides. More complex profiles can include all of the above features plus dispersed calcareous nodules and in some cases thin (<40 cm) layers of nodular stage 3 calcrete (Machette, 1985) (Figs. 6f, 8a, b). A 0.02-1.50 m interval of green-grey to black claystone commonly overlies individual soil profiles (Figs. 6f, 8a). Strata immediately above these claystones commonly exhibit much less

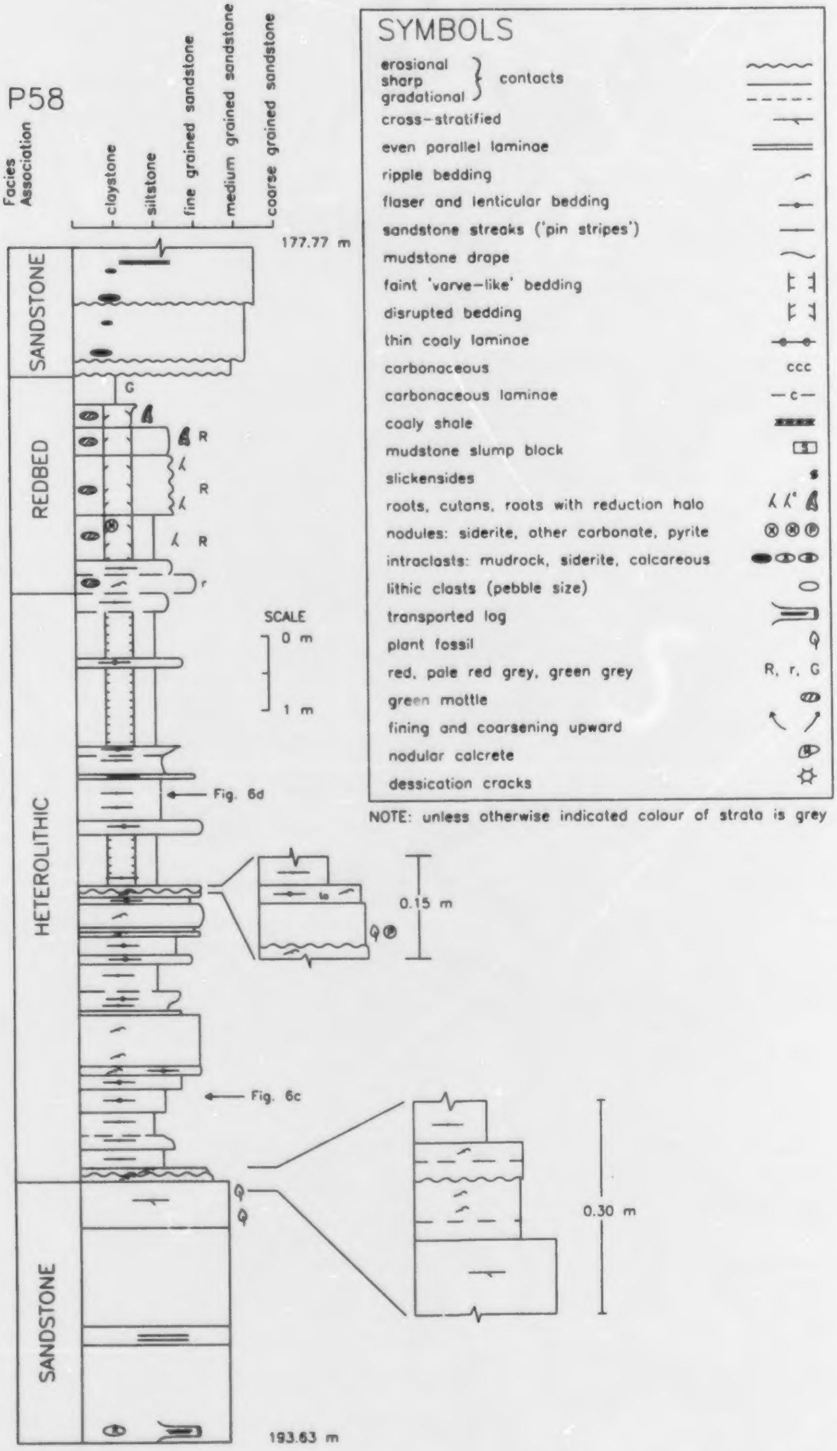

P58
Facies Association
claystone
siltstone
fine grained sandstone
medium grained sandstone
coarse grained sandstone
177.77 m
SANDSTONE
REDBED
HETEROLITHIC
SANDSTONE
G
R
R
R
r
SCALE
0 m
1 m
Fig. 6d
Fig. 6c
0.15 m
0.30 m
193.63 m
SYMBOLS
erosional
sharp
gradational
contacts
cross-stratified
even parallel laminae
ripple bedding
flaser and lenticular bedding
sandstone streaks ('pin stripes')
mudstone drape
faint 'varve-like' bedding
disrupted bedding
thin coaly laminae
carbonaceous
ccc
carbonaceous laminae
—c—
coaly shale
mudstone slump block
slickensides
roots, cutans, roots with reduction halo
nodules: siderite, other carbonate, pyrite
intraclasts: mudrock, siderite, calcareous
lithic clasts (pebble size)
transported log
plant fossil
red, pale red grey, green grey
R, r, G
green mottle
fining and coarsening upward
nodular calcrete
dessication cracks
NOTE: unless otherwise indicated colour of strata is grey

Figure 7. Detailed profiles illustrating the sedimentology of the heterolithic facies association and the typical vertical transition from channel sandstones through heterolithic facies to redbeds. See Figure 3 for location.

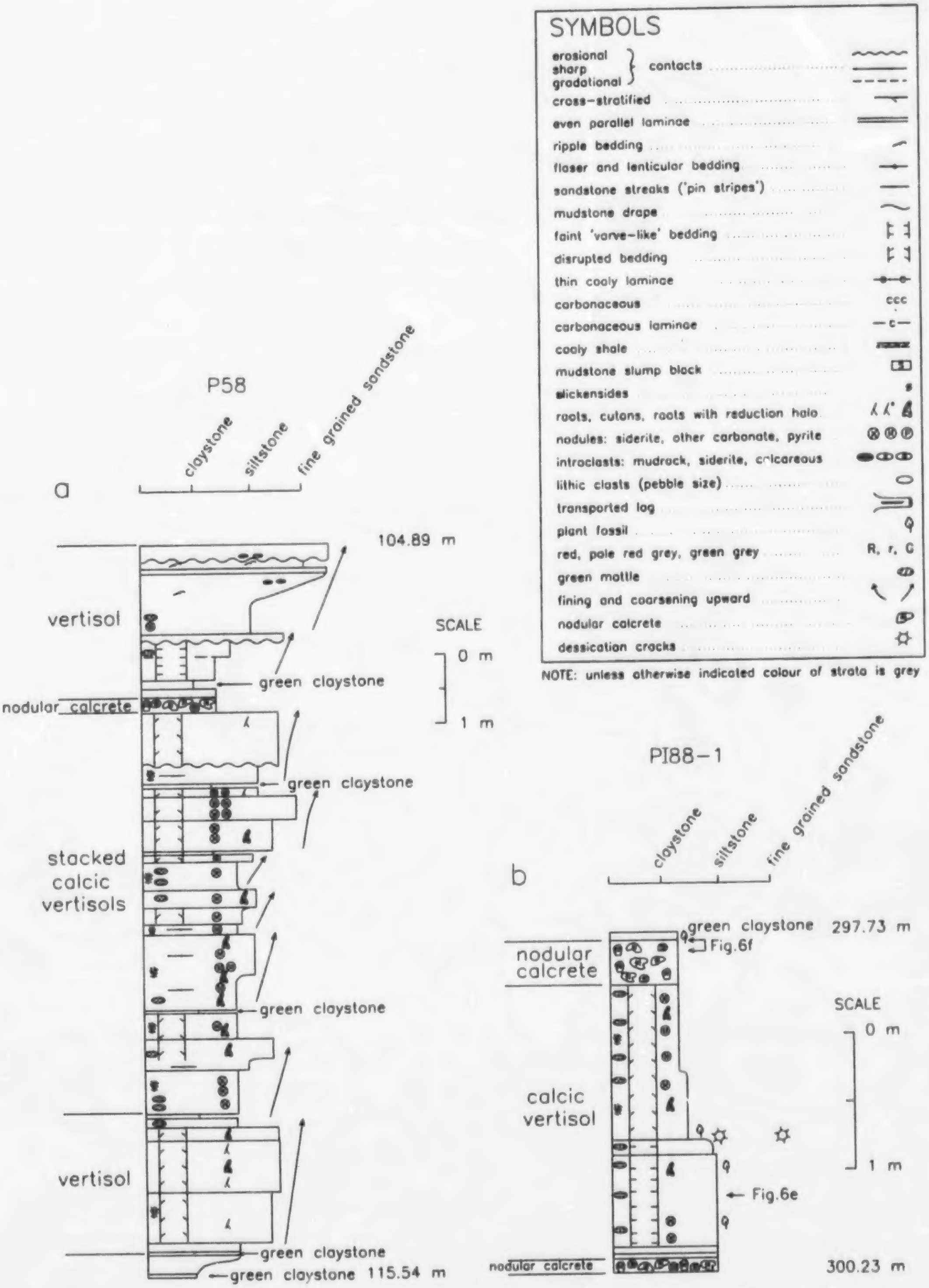

SYMBOLS
erosional
sharp
gradational
contacts
cross-stratified
even parallel laminae
ripple bedding
flaser and lenticular bedding
sandstone streaks ('pin stripes')
mudstone drape
faint 'varve-like' bedding
disrupted bedding
thin coaly laminae
carbonaceous
carbonaceous laminae
coaly shale
mudstone slump block
slickensides
roots, cutans, roots with reduction halo
nodules: siderite, other carbonate, pyrite
introclasts: mudrock, siderite, calcareous
lithic clasts (pebble size)
transported log
plant fossil
red, pale red grey, green grey
R, r, G
green mottle
fining and coarsening upward
nodular calcrete
dessication cracks
NOTE: unless otherwise indicated colour of strata is grey
P58
a
claystone
siltstone
fine grained sandstone
104.89 m
vertisol
SCALE
0 m
1 m
green claystone
nodular calcrete
green claystone
stacked calcic vertisols
green claystone
vertisol
green claystone
green claystone 115.54 m
PI88-1
b
claystone
siltstone
fine grained sandstone
green claystone 297.73 m
nodular calcrete
Fig.6f
SCALE
0 m
calcic vertisol
1 m
Fig.6e
nodular calcrete
300.23 m

Figure 8. Detailed profiles illustrating the sedimentology of the redbed association. (a) Coasening upward cycles and stacked vertisols. (b) Two nodular calcrete layers separated by a calcic vertisol. For locations see Figure 3.

disruption and homogenization of bedding than strata immediately below (Fig. 8a).

Coal-Bearing Association

The coal-bearing facies association (17 m maximum thickness) accounts for only 4% of the Malagash Formation strata and generally occurs directly above a sandstone association unit (Fig. 3). Typically the coal-bearing association consists of 0.5-3.0 m thick sequences of carbonaceous mudrock coarsening upward to grey siltstone to fine grained sandstone (Fig. 9). Coal layers are rare and coaly shales are more commonly developed; these are less than 0.3 m thick. Nodular carbonate and siderite concretions occur locally and fossil plant impressions are rare to occasional.

Bedding is generally very disrupted by roots, however, ripple bedding, lenticular laminae and 'pin stripes' are preserved within some siltstone and sandstone beds. Varve-like laminae consisting of fine grained sandstone and claystone couplets (2 cm maximum thickness) were observed within some of the less disrupted, coarser grained units.

Depositional Environments

Sandstone Association

Previous workers have described the channel sandstones of the Malagash Formation as deposits of a wide spectrum of river systems including: braided to meandering (Yeo and Ruixiang, 1987), braided or anastomosing (Palmer, 1991), and anastomosing (Ryan and Boehner, 1994). Indecision regarding the origin of these channel sandstones can largely be attributed to the following: (1) the paradox of having what appear to be thick braided river deposits interbedded with thick overbank successions (ie. redbed association), and (2) insufficient stratigraphic control to define the geometry of individual sand bodies.

A general overall lack of vertical change in type and scale of sedimentary structures and low variance in sediment transport directions suggests the thick multistoried sandstones of this association are not deposits of meandering rivers. An anastomosed origin also appears unlikely because modern anastomosing systems generally have a very high percentage (60-90%) of associated wetland and floodplain deposits (Smith, 1983). In contrast, floodplain deposits (redbed and coal-bearing facies) appear to comprise only about 33% of the Malagash Formation. Smith (1983) reported modern anastomosed channel deposits range from 5-15 m in thickness. This is considerably thinner than a maximum thickness of 60 m for the channel sandstones of the Malagash Formation. A final argument against an anastomosed origin is that the thick channel sandstones appear to maintain their thickness laterally between drillholes PIC 88-1 and PIC 88-2.

In light of the above, a braided origin appears most probable for the thick multistoried channel sandstones of the Malagash Formation. Campbell (1976) described similar multistoried braided channel deposits from the Morrison Formation, northwestern New Mexico, with each storey (average 4 m) consisting of intra- and extraformational lags overlain by trough cross-stratified sands. However, the Morrison Formation contains significantly less fine facies than the Malagash Formation. This suggests some differences in fluvial style may have existed during formation of the two formations. One possible difference is suggested by the thin mud drapes that occur within some thick Malagash sandstones. Similar mudstone drapes have been cited by numerous authors as evidence of tidal influence.

The thin and thick sandstone units of this association of the Malagash Formation have many features in common suggesting they have a similar origin. A crevasse channel or overbank origin for the thin sandstones is unlikely given the common occurrence of intraformational clasts and absence of roots. It appears more likely that the thin sandstones were deposited in river channels that appeared braided at flood stage and accumulated muds at lower stages. The common occurrence of grey intraformational clasts may represent reworking of within channel fines (e.g. heterolithic facies) as opposed to erosion of overbank deposits. Mudstone drapes, thin mudstone interbeds, and the occurrence of units that are transitional in character to the heterolithic facies association may suggest a possible tidal influence (see discussion of heterolithic facies below).

Heterolithic Facies Association

The presence of *Ammotium* in one sample of the heterolithic association indicates the depositional environment was at least periodically brackish and suggests estuarine-type deposition (Wightman, 1995). *Ammotium* has also been used to infer estuarine and marine influences in other Carboniferous sequences in Nova Scotia (Gibling and Wightman, 1994; Wightman *et al.*, 1993, 1994a, 1994b; Archer *et al.*, 1995).

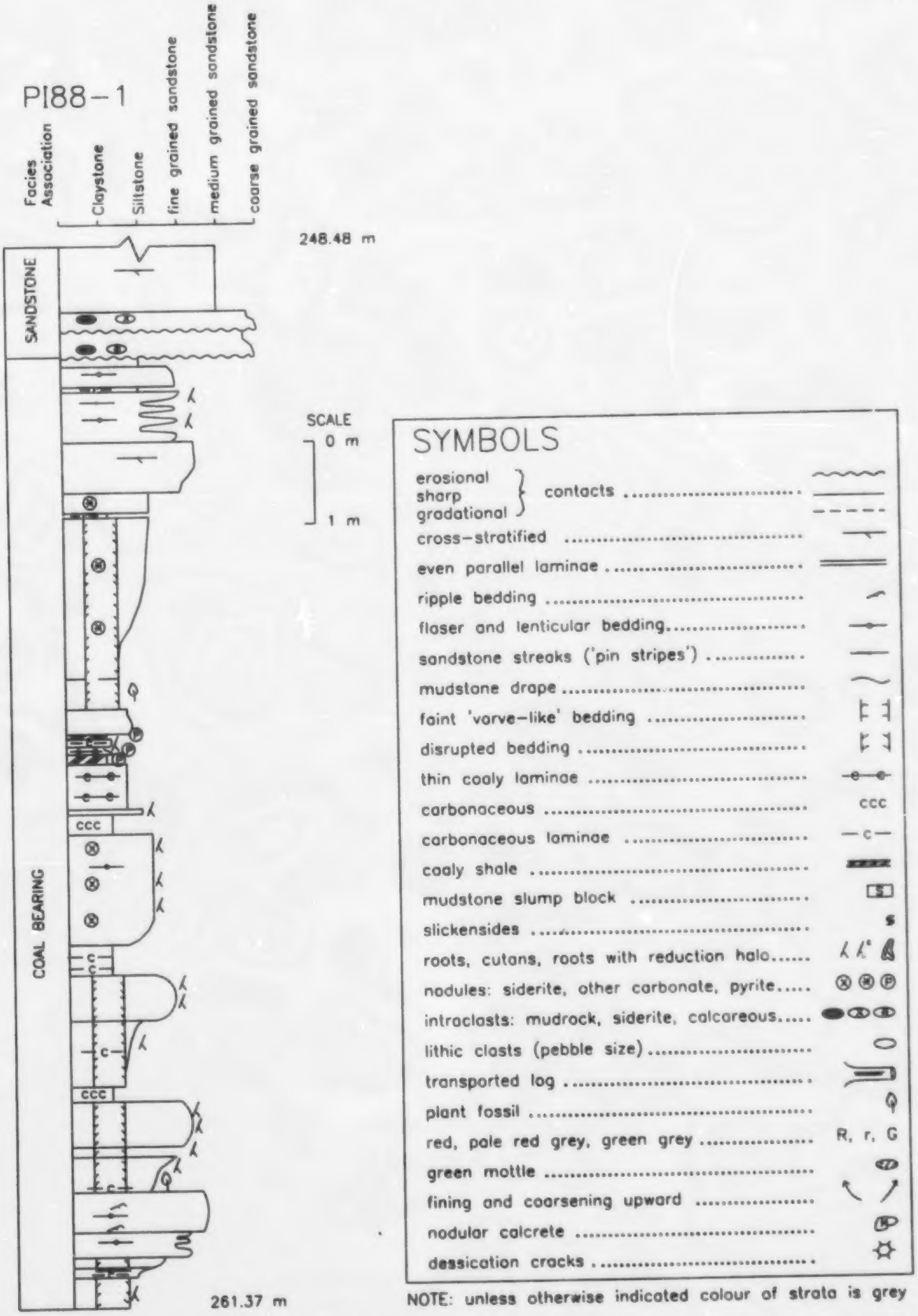

PI88-1
Facies Association
Claystone
Siltstone
fine grained sandstone
medium grained sandstone
coarse grained sandstone
248.48 m
SANDSTONE
COAL BEARING
ccc
c
ccc
261.37 m
SCALE
0 m
1 m
SYMBOLS
erosional
sharp
gradational
contacts
cross-stratified
even parallel laminae
ripple bedding
flaser and lenticular bedding
sandstone streaks ('pin stripes')
mudstone drape
faint 'varve-like' bedding
disrupted bedding
thin coaly laminae
carbonaceous
ccc
carbonaceous laminae
—c—
coaly shale
mudstone slump block
S
slickensides
s
roots, cutans, roots with reduction halo
nodules: siderite, other carbonate, pyrite
intraclasts: mudrock, siderite, calcareous
lithic clasts (pebble size)
transported log
plant fossil
red, pale red grey, green grey
R, r, G
green mottle
fining and coarsening upward
nodular calcrete
dessication cracks
NOTE: unless otherwise indicated colour of strata is grey

Figure 9. Detailed profile illustrating the sedimentology of the coal-bearing association. See Figure 3 for location.

Flaser, lenticular and 'pin stripe' bedding characterize the heterolithic facies and are typical of tidal influences (e.g. Reineck and Wunderlich, 1968; Klein, 1977; Allen, 1991). In terms of process-oriented sedimentology, however, such facies merely indicate repeated, short-term variations in flow velocity. Thus such facies have also been reported from modern lacustrine deltas (e.g. Coleman, 1966; Dunne and Hempton, 1984) and fluvially dominated interdistributary bays (e.g. Coleman and Prior, 1982). The heterolithic facies of lacustrine and bay fill deposits generally form part of thick, fine grained successions composed of metre scale, coarsening upward sequences (Coleman and Prior, 1982; Tye and Coleman, 1989). In contrast the heterolithic facies of the Malagash Formation usually abruptly overly channel sandstones and do not exhibit any tendency to coarsen upward at the metre scale.

Fine grained heterolithic facies (Figs. 6c, 6d, 7) that are closely associated with channel sandstones have been interpreted as estuarine deposits by a variety of authors (e.g. Wood and Hopkins, 1989; Shanley *et al.*, 1992; Hettinger, 1995). This is largely based on description of similar facies from modern estuaries such as the tidal point bar deposits described by Allen (1991) in the Gironde Estuary of France. Excellent examples of Carboniferous heterolithic facies form part of 'clastic wedges' in the coal-measures of the United States midcontinent (Wanless, 1964; Gluskoter and Hopkins, 1979). These wedges were originally interpreted largely as the products of fluvial, overbank or deltaic deposition (e.g. Edwards *et al.*,1979; Eggert, 1987; Burke *et al.*, 1987). Recently they have been re-interpreted to be tidally influenced, estuarine-related facies based on recognition of tidal rhythmites within the heterolithic facies (Archer and Kvale, 1993; Archer *et al.*, 1994a).

Although the heterolithic facies of the Malagash Formation do not appear to contain tidal rhythmites, they are lithologically very similar to the heterolithic facies of the midcontinental United States. In addition, both generally exhibit very little bioturbation. This suggests that although the heterolithic facies might be tidally influenced from a depositional-energy perspective, they may not have commonly been subjected to marine salinities. This may, in part, explain why only one sample of the heterolithic facies contained agglutinated foraminifera. Tidal effects can extend well beyond saline incursions in some modern estuaries. In the Gironde Estuary of France, for example, tides affect sedimentation up to 50 km inland from the salt intrusion (Allen, 1991). Tidal effects within the Seven Estuary of southeastern England extend inland for about 120 km and in the St. Lawrence Estuary of Canada, such effects extend over 700 km inland (Archer *et al.*, 1994b). The Amazon River experiences tidal effects at least 735 km upriver from the mouth without any accompanying salinity changes inland (Officer, 1976, p. 379).

Redbed Association

The fine facies of the redbed association have many attributes of vegetated floodplain deposits including: (1) disruption of bedding by roots, (2) paleosols, (3) fine grained strata, and (4) millimetre- to centimetre-scale rhythmites. The rare, thick sandstones of this association, that are trough crossbedded at the base, ripple bedded toward the top and fine upward overall, are interpreted as meandering river deposits. Many of the coarsening-upward sequences (Fig. 8a) of the redbed association appear to have formed due to progradation of overbank deposits onto floodplains (e.g. Bridge, 1984; Farrell, 1987). The red mudrocks, with highly disrupted bedding, are similar to well-drained swamp deposits ('rooted clays') of the lower Mississippi River valley described by Farrell (1987). Although the well-drained swamp deposits of the Mississippi River valley are not as oxidized as the 'disrupted' red mudrocks of the Malagash Formation, both are characterized by the following: (1) root mottles, (2) carbonate nodules, (3) extensive disruption of primary stratification, (4) poor preservation of organic material, and (5) local preservation of thin (millimetre scale), siltstone-claystone rhythmites. The green-grey to black mudrocks that form a minor part of the redbed association are believed to be analogous to the poorly drained swamp deposits of the Mississippi backswamps (cf. Coleman, 1966; Krinitzsky and Smith, 1969; Farrell, 1987). Rhythmically layered silty-sandstones of the redbed association are similar to levee and splay sediments of the Mississippi River valley described by Farrell (1987).

The redbed facies may also include some lacustrine-delta deposits that are broadly analogous to recent examples described from the Atchafalaya Basin by Tye and Coleman (1989). The lacustrine-delta deposits in the Atchafalaya Basin form sequences that coarsen upward from clays to fine to medium sands. Soils are not as well developed in the lacustrine deposits of the Atchafalaya Basin, probably because lake levels do not fluctuate significantly (Tye and Coleman, 1989). During deposition of the Malagash redbeds seasonal fluctuations in lake levels could have resulted in significant overprinting of lacustrine delta deposits by soils. As lakes became infilled plants would have colonized the surface of lacustrine deltas causing the underlying sediment to be disrupted by roots.

The redbeds of the Malagash Formation are generally much more oxidized than the overbank deposits of the lower Mississippi River valley and lacustrine-delta deposits of the Atchafalaya Basin. This may imply better drainage during deposition of the Malagash Formation redbeds. Alternatively a more strongly seasonal climate may be responsible for reddening of the Malagash mudrocks. The paleosols of the redbed facies are classified as vertisols based on the occurrence of pedogenic slickensides and nodular calcrete (Figs. 6f, 8a, b). The paleosols rich in pedogenic carbonate are probably more accurately described as calcic vertisols (cf. Mack *et al.*, 1993). Modern soils analogous to calcic vertisols currently form in subhumid to semiarid, strongly seasonal, tropical to subtropical climates with a rainfall of 180-1250 mm per year (Ahmad, 1988; Dudal and Eswaran, 1988; Retallack, 1990).

Coal-Bearing Association

The coal-bearing association is interpreted to have a similar origin to the redbed association. Lack of reddening suggests reducing conditions may have predominated because of a more stable water table. The coarsening upward sequences capped by organic-rich mudrocks or impure coals can be explained by either progradation of overbank deposits or by deltaic infilling of shallow lakes followed by development of swamps. A more continually wet climate or water table stabilization, related to local topographic variation on a floodplain, could explain lack of oxidation within the coal-bearing association.

Discussion

Bimodal tidal bedding, with current-reversal features such as herringbone cross-stratification, or ripples with reverse-flow crests, have not been observed within the Malagash Formation. This suggests, that the paleoflow regime was dominated by fluvial-transport despite the possible tidal influences indicated by agglutinated foraminifera, heterolithic facies, and rare mudstone drapes. The dominance of fluvial processes over tidal processes would be consistent with the inland depositional setting of the Malagash Formation. It is not surprising, however, that evidence of tidal influence may be preserved within the Malagash Formation. Tidal effects can be propagated for hundreds of kilometres upstream in large-scale river systems (Allen, 1991; Shanley *et al.*, 1992; Archer *et al.*, 1994b).

The absence of obvious Westphalian C-D marine strata in the Gulf of St. Lawrence Basin suggests that tidal effects extended a considerable distance from the paleoshoreline. Although no marine strata have been recognized, Wightman *et al.* (1994a) reported agglutinated foraminifera of estuarine origin are common in the late Westphalian Inverness Formation (Fig. 4). They also determined that the distribution of foraminifera assemblages indicates an increasing marine influence toward northern areas of the Gulf of St. Lawrence Basin. This suggests tidal influence on sedimentation may have extended over 200 km inland during deposition of the Malagash Formation.

The exact nature of the estuaries that may have propagated tidal effects into the study area, during deposition of the Malagash Formation, is difficult to determine. An estuary is formed when a rise in sea level drowns an alluvial valley or causes the lower reaches of a river to become tidally influenced. It is difficult to distinguish paleovalley fills from fluvial facies that were deposited with minimal valley development. Recognition of paleovalleys requires either excellent outcrop exposure (e.g. Gibling and Wightman, 1994) or closely spaced drilling (e.g. Wood and Hopkins, 1989). We are currently unable to define paleovalleys in the study area. However, Gibling and Wightman (1994) have attributed formation of paleovalleys in the Late Carboniferous coal measures of the neighbouring Sydney Basin (see Fig. 1 for location) to a fall in sea level. This allows for the possibility that paleovalleys also developed in the Gulf of St. Lawrence Basin in response to Westphalian C-D sea level changes. Global sea level changes related to Gondwanan glaciation-deglaciation were apparently considerable during this period. Estimates of the magnitude of this eustatic flux have been based on: (1) theoretical Gondwanan ice-volume computations (Crowley and Baum, 1991), (2) depth assessments of specific highstand lithofacies (Heckel, 1986), and (3) determination of the depths of incision within lowstand paleovalleys (Archer *et al.*, 1994b). These three approaches all yield glacio-eustatic flux estimates of at least 30 m and as much as 100 m. Even considerably inland depositional systems, similar to those of the Malagash Formation, could have been affected by such significant eustatic changes.

High amplitude glacio-eustatic flux, coupled with an active tectonic setting, favours significant changes in sea level (cf. Posamentier *et al.*, 1988) during deposition of the Malagash Formation. A drop in sea level would have caused erosion, fluvial incision and the possible formation of alluvial valleys. During lowstands, much sand and all of the muddy sediment could have by-passed the upland setting of the study area. However, Gibling and

Wightman (1994) suggested Late Carboniferous paleovalleys in the Sydney Basin were infilled entirely with alluvial sediments during lowstand and early transgression. They attributed this, in part, to an abundant sediment supply that was sourced from the northern and central Appalachians (Gibling *et al.*, 1992). It is possible that the braided river deposits of the Malagash Formation also accumulated during a lowstand. The tendancy for muddy facies, that we have interpreted to be estuarine deposits, to cap the braided river deposits in the Malagash Formation, however, indicates they may have been deposited during a rise in sea level. High rates of sediment supply during a slow rise in sea level may have forestalled marine transgression and facilitated deposition of thick braided river sands. When the rate of sea level rise increased, tidal effects moved inland and heterolithic facies were emplaced over braided river deposits.

Shanley *et al.* (1992) suggested deposition of tidaly influenced facies immediately above braided river deposits requires a rapid rise in base level. A rapid rise in base level results in minimal alluvial aggradation because sediment supply is unable to keep up with sea level rise. As the rate of base level rise slows, rivers gradually adjust their profiles creating significant accommodation space for alluvial sedimentation (Shanley *et al.*, 1992). The meandering river and floodplain deposits of the redbed and coal-bearing associations would probably have been deposited during this period. It appears unlikely that floodplain sediments accumulated adjacent to estuarine or braided sections of the Malagash Formation rivers. Tides generally tend to dampen floods and effectively trap muds within estuarine channels (Allen, 1991). Therefore, when the rivers of the Malagash Formation were in flood stage, minimal amounts of floodplain sediment would have accumulated in tidally influenced sections. Although thick floodplain sequences can accumulate adjacent to braided rivers (McLean and Jerzykiewicz, 1978), it is not common. Therefore, the redbed and sandstone association facies are probably not coeval deposits.

Basinward, Gibling *et al.* (1994) described an alternation of braided river deposits and mudrock dominated successions in the Inverness Formation (Fig. 4) that is similar to the alternation of channel sandstones and fine facies in the Malagash Formation. They suggested that the thick (50-100 m) multistoried sandstones (braided river deposits) of the Inverness Formation were not coeval with the intervening, thick, grey mudrock and coal dominated units. They inferred an alternation between braided channel and 'wetland' phases caused by differential subsidence or eustasy, but did not recognize any tidal sediments. The similarity between the channel sandstone facies of the Malagash and Inverness formations suggests significant progradation of channel deposits basinward following a lowering of base level. The redbed and poorly developed coal-bearing facies associations of the Malagash Formation are probably the better drained upland equivalents of the well-developed, grey mud rock dominated coal-bearing units (floodplain, lake, swamp and mire deposits) of the Inverness Formation.

Although changes in base level played an important role during deposition of the Malagash Formation, climate also appears to have significantly influenced sedimentation. In the Westphalian, Nova Scotia was in a low latitude, near equatorial position, which has been estimated to be approximately 5°S (Scotese and McKerrow, 1990). Distribution of coals has been used to suggest that the region lay within a zonal equatorial wet-climate belt (Witzke, 1990). Conversely, the assembly of Pangea would have predisposed Nova Scotia to a monsoonal climate (Kutzbach and Gallimore, 1989; Rowley *et al.*, 1985). Supportive evidence for monsoonal conditions comes from the presence of calcrete-bearing vertisols which have commonly been used as indicators of tropical seasonality (e.g. Bridges, 1970; Dudal and Eswaran, 1988). Calcareous vertisols have also been reported from the Westphalian C-D to Stephanian of the Sydney Basin (Gibling and Wightman,1994).

In areas of strong seasonality, rivers exhibit extreme variations in seasonal levels and clastic flux. If the Malagash Formation rivers experienced such variations in seasonal discharge, the range of tidal influence may have fluctuated considerably throughout the year. In the Gironde Estuary, for example, the tidal range fluctuates approximately 30 km between high and low discharge (Allen, 1991). Evidence of tidal influence is generally only preserved down stream from the limit of tidal current reversal during high river discharge. This suggests muddy tidal sediment deposited upstream from this point, during low river discharge, must be completely eroded and reworked. The abundance of grey intraclasts, within the thick multistoried sandstones of the Malagash Formation, may signify, in part, complete erosion and reworking of heterolithic facies that accumulated in the upper reaches of estuaries between major floods. Thus, although deposition of the heterolithic facies may have been a common form of channel sedimentation, the rapidly deposited channel sands could have had a much higher net potential for preservation. Preservation of heterolithic facies in the study area would have required sandy sediment being diverted from a channel during partial abandonment or a rise in base level that shifted estuarine systems significantly inland.

Conclusions

Despite the upland character of the Malagash Formation, the recognition of potential tidal sediments suggests that significant base level flux may have occurred during the Westphalian C-D. Tectonic subsidence undoubtedly exerted a strong control on these base level changes. However, comparison to age equivalent strata in other areas, such as the United States midcontinent, indicates that this time period exhibited major glacio-eustatic controls on base level as well, even within such a tectonically active area as Nova Scotia. The preservation potential of tidal sediments may have been reduced by a monsoonal climate. Seasonal flushing of estuaries may have eroded heterolithic facies that were deposited in the upper parts of estuaries during periods of low discharge.

Along with an increasing degree of marine influences being recognized in many coal measures throughout the world, this paper documents what appear to be subtle indicators of distal paralic influences within an upland sequence. These marine influences were manifested by generally nonbioturbated heterolithic facies, that contain estuarine-type agglutinated foraminifera. In most cases the heterolithic facies were deposited immediately above channel sandstones that contain rare mudstone drapes. Recognition and understanding of the significance of these criteria should provide useful information for the evaluation of other upland Carboniferous sequences. In particular, the delineation of marine-influenced facies should assist in the potential application of sequence-stratigraphic interpretations of such units, which have previously been interpreted as exclusively characterized by nonmarine conditions.

Acknowledgments

Support for this collaborative research was provided by a variety of sources. A. W. Archer was supported by a Faculty Development Award from Kansas State University. Winton Wightman provided identifications of the agglutinated foraminifera. Trent Rehill provided very useful discussion and information regarding the regional stratigraphy of the Gulf of St. Lawrence Basin. Early drafts of this manuscript were reviewed and greatly improved by suggestions from John Calder and Keith B. Miller.

References

Ahmad, N. 1988: The management of vertisols in the humid tropics, Chapter 6; *in* Vertisols: Their Distribution, Properties, Classification and Management, eds. L. P. Wilding and Ruben Puentes; Technical Monograph, No. 18, Soil Management Support Services (1988), Texas A&M University, 193 p.

Allen, G. P. 1991: Sedimentary processes and facies in the Gironde Estuary: a recent example of macrotidal estuarine systems; *in* Clastic Tidal Sedimentology, eds. D. G. Smith, G. E. Reinson, B. A. Zaitlin and R. A. Rahmani; Canadian Society of Petroleum Geologists, Memoir 16, p. 29-40.

Archer, A. W., Feldman, H. R., Kvale, E. P. and Lanier, W. P. 1994a: Pennsylvanian (Upper Carboniferous) fluvio- to tidal estuarine coal-bearing systems: delineation of facies transitions based upon physical and biogenic sedimentary structures; Palaeogeography, Palaeoclimatology, Palaeoecology, v. 106, p. 171-185.

Archer, A. W. and Kvale, E. P. 1993: Origin of gray-shale lithofacies ("clastic wedges") in U.S. midcontinental coal measures (Pennsylvanian): an alternative explanation; *in* Modern and Ancient Coal-Forming Environments: Boulder, Colorado, eds. J. C. Cobb and C. B. Cecil; Geological Society of America, Special Paper 286, p. 181-198.

Archer, A. W., Lanier, W. P. and Feldman, H. R. 1994b: Stratigraphy and depositional history within incised paleovalley fills and related facies, Douglas Group (Missourian/Virgilian; Upper Carboniferous) of Kansas, U.S.A.; Society of Economic Paleontologists and Mineralogists, Special Publication 51, p. 175-190.

Archer, A. W., Wightman, W. G., Calder, J. H., Gibling, M. R., Naylor, R. D. and Reid, D. R. 1995: Invertebrate trace fossils and agglutinated foraminifera as indicators of marine influence within the classic Carboniferous section at Joggins, Nova Scotia, Canada; Canadian Journal of Earth Sciences, v. 32, p. 2027-2039.

Bell, W. A. 1940: The Pictou Coalfield, Nova Scotia; Geological Survey of Canada, Memoir 225, 80 p.

Bird, D. J. 1987: The depositional environment of the Late Carboniferous, coal-bearing Sydney Mines

Formation, Point Aconi area, Cape Breton Island, Nova Scotia; unpublished M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia, 343 p.

Bridge, J. S. 1984: Large-scale facies sequences in alluvial overbank environments; Journal of Sedimentary Petrology, v. 54, p. 583-588.

Bridges, E. M. 1970: World Soils; Cambridge University Press, 89 p.

Burke, M. K., Deshowitz, M. P. and Utgaard, J. E. 1987: Facies and depositional environments of the Energy Shale Member (Pennsylvanian) and their relationships to low-sulfur coal deposits in southern Illinois; Journal of Sedimentary Petrology, v. 57, p. 1060-1067.

Calder, J. H. 1998: The Carboniferous evolution of Nova Scotia; *in* The Past is the Key to the Present, eds. D. J. Blundell and A. C. Scott; Geological Society of London, Special Publications 143, p. 261-302.

Campbell, C. V. 1976: Reservoir geometry of a fluvial sheet sandstone; American Association of Petroleum Geologists Bulletin, v. 60, p. 1009-1020.

Chandler, F. W. 1995: Geological mapping in the Stellarton Gap, (NTS 11E/7, 9, 10, 15), a status report; Atlantic Geoscience Society colloquium and Annual General Meeting, Antigonish, Nova Scotia, Program and Abstracts, St. Francis Xavier University, Antigonish, p. 9-10.

Coleman, J. M. 1966: Ecological changes in a massive freshwater clay sequence; Transactions, Gulf Coast Association of Geological Societies, v. 16, p. 159-174.

Coleman, J. M. and Prior, D. B. 1982: Deltaic environments of deposition; *in* Sandstone Depositional Environments, eds. P. A. Scholle and D. Spearing; American Association of Petroleum Geologists, Memoir 31, p. 139-178.

Crowley, T. J. and Baum, S. K. 1991: Estimating Carboniferous sea-level fluctuations from Gondwanan ice extent; Geology, v. 19, p. 975-977.

Dudal, R. and Eswaran, H. 1988: Distribution properties and classification of vertisols; *in* Vertisols: Their Distribution, Properties, Classification and Management, eds. L. P. Wilding and Ruben Puentes; Technical Monograph, No. 18, Soil Management Support Services (1988), Texas A&M University, p. 1-22.

Dunne, L. A. and Hempton, M. R. 1984: Deltaic sedimentation in the Lake Hazar pull-apart basin, southeastern Turkey; Sedimentology, v. 31, p. 401-412.

Edwards, M. J., Langenheim, R. L., Jr., Nelson, W. J. and Ledvina, C. T. 1979: Lithologic patterns in the Energy Shale Member and the origin of "rolls" in the Herrin (No. 6) Coal Member, Pennsylvanian, in the Orient No. 6 Mine, Jefferson County, Illinois; Journal of Sedimentary Petrology, v. 49, p. 1005-1014.

Eggert, D. L. 1987: Earlier sediment differential compaction in Gibson County, Indiana; International Journal of Coal Geology, v. 8, p. 305-314.

Farrell, K. M. 1987: Sedimentology and facies architecture of overbank deposits of the Mississippi River, False River Region, Louisiana; *in* Recent Developments in Fluvial Sedimentology, eds. F. G. Ethridge, R. M. Flores and M. D. Harvey; Society of Economic Paleontologist and Mineralogists, Special Publication 39, p. 111-120.

Fralick, P. W. and Schenk P. E. 1981: Molasse deposition and basin evolution in a wrench tectonic setting: the late Paleozoic, Eastern Cumberland Basin, Maritime Canada; *in* Sedimentation and Tectonics in Alluvial Basins, ed. A. D. Miall; Geological Association of Canada, Special Paper 23, p. 77-97.

Gibling, M. R. and Bird, D. J. 1994: Alluvial-dominated cyclothems in the Late Carboniferous of Atlantic Canada; Geological Society of America Bulletin, v. 106, p. 105-117.

Gibling, M. R., Calder, J. H., Ryan, R., Van De Poll, H. W. and Yeo, G. 1992: Late Carboniferous and Early Permian drainage patterns in Atlantic Canada; Canadian Journal of Earth Sciences, v. 29, p. 338-352.

Gibling, M. R., Marchioni, D. L. and Kalkreuth, W. D. 1994: Detrital and organic facies of Upper Carboniferous strata at Mabou Mines, western Cape Breton Island, Nova Scotia; Geological Survey of Canada, Current Research 1994-D, p. 51-56.

Gibling, M. R. and Wightman, W. G. 1994: Paleovalleys and protozoan assemblages in a Late Carboniferous cyclothem, Sydney Basin, Nova Scotia; Sedimentology, v. 41, p. 699-719.

Gluskoter, H. J. and Hopkins, M. E. 1979: Distribution of sulfur in Illinois coals; *in* Depositional Environments in Parts of the Carbondale Formation - Western and Northern Illinois, eds. W. H. Smith, R. B. Nance, R. G. Johnson, M. E. Hopkins and C. W. Shabica; Illinois Geological Survey, Guidebook Series 8, p. 89-95.

Hacquebard, P. A. 1986: The Gulf of St. Lawrence Carboniferous Basin: The largest coalfield of Eastern Canada; Canadian Institute of Mining Bulletin,v. 79, p. 67-78.

Hacquebard, P. A., Birmingham, T. F. and Donaldson, J. R. 1967: Petrography of Canadian coals in relation to environment of deposition; *in* Energy, Mines, and Research Symposium on Science and Technology of Coal, Ottawa, p. 84-97.

Hacquebard, P. A. and Donaldson, J. R. 1969: Carboniferous coal deposition associated with flood-plain and limnic environments in Nova Scotia; Geological Society of America, Special Paper 114, p. 143-191.

Heckel, P. H. 1986: Sea-level curve for Pennsylvanian eustatic marine transgressive-regressive depositional cycles along the midcontinent outcrop belt, North America; Geology, v. 14, p. 330-334.

Hettinger R. D. 1995: Sedimentological descriptions and depositional interpretations, in sequence straigraphic context, of two 300-metre cores from the Upper Cretaceous Straight Cliffs Formation, Kaiparowits Plateau, Kane County, Utah; United States Geological Survey, Bulletin 2115-A, 32 p.

Klein, G. deV. 1977: Clastic Tidal Facies; Continuing Education Publishing Company (CEPCO), Champaign, Illinois, 149 p.

Krinitzsky, E. L. and Smith, F. L. 1969: Geology of backswamp deposits in the Atchafalaya Basin, Louisiana; U.S. Army Corps of Engineers, Waterways Experiment Station, Technical Report S-69-8, Vicksburg, Mississippi, 26 p.

Kutzbach, J. E. and Gallimore, R. G. 1989: Pangean climates, megamonsoons of the megacontinent; Journal of Geophysical Research, v. 94, No. 3D, p. 3341-3357.

Machette, M. N. 1985: Calcic soils of the southwestern United States; *in* Soils and Quaternary Geology of the southwestern United States, ed. D. L. Weide; Geological Society of America, Special Paper 203, p. 1-21.

Mack, G. H., James, W. C. and Monger, C. H. 1993: Classification of paleosols; Geological Society of America Bulletin, v. 105, p. 129-136.

McLean, J. R. and Jerzykiewicz T. 1978: Cyclicity, tectonics and coal: Some aspects of fluvial sedimentology in the Brazeau-Paskapoo Formations, Coal Valley area, Alberta, Canada; *in* Fluvial Sedimentology; Canadian Society of Petroleum Geologists, Memoir 5, p. 441-468.

Naylor, R. D., Calder, J. H., Ryan, R. J. and Martel, T. A. 1992: Controls on formation of Upper Carboniferous coals in the intermontane Stellarton and Cumberland basins of Atlantic Canada; Proceedings of the Canadian Coal and Coalbed Methane Geoscience Forum, Parksville, British Columbia, Canada, p. 365-397.

Naylor, R. D., Kalkreuth, W. D., Smith, W. D. and Yeo, G. M. 1989: Stratigraphy, sedimentology and depositional environments of the coal-bearing Stellarton Formation, Nova Scotia; Geological Survey of Canada, Paper 89-8, p. 2-13.

Officer, C. B. 1976: Physical Oceanography of Estuaries and Associated Coastal Water; Willey-Interscience, New York, 465 p.

Palmer, S. E. 1991: Carbonates and associated sediments in the Merigomish Formation of the Stellarton Gap, Nova Scotia; B.Sc. honours thesis, Department of Geology, Saint Mary's University, Halifax, Nova Scotia.

Posamentier, H. W., Jervey, M. T. and Vail, P. R. 1988: Eustatic controls on clastic deposition I-Conceptual framework; *in* Sea Level Changes: An Integrated Approach, eds. C. K. Wilgus, B. S. Hastings, C. G. St. C. Kendall, H. W. Posamentier, C. A. Ross and J. C. Van Wagoner; Special Publication of the Society of Economic Paleontologists and Mineralogists, v. 42, p. 109-124.

Reineck, H. E. and Wunderlich, F. 1968: Classification and origin of flaser and lenticular bedding; Sedimentology, v. 11, p. 99-104.

Retallack, G. J. 1990: Soils of the Past, An Introduction to Paleopedology; Unwin Hyman, Publishing, 520 p.

Rowley, D. B., Raymond, A., Totman Parrish, J., Lottes, A. L., Scotese, C. R. and Ziegler, A. M. 1985: Carboniferous paleogeographic, phytogeographic and paleoclimatic reconstructions; International Journal of Coal Geology, v. 5, p. 7-42.

Ryan, R. J. and Boehner, R. C. 1994: Geology of the Cumberland Basin, Cumberland, Colchester and Pictou counties, Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branches, Memoir 10, 212 p.

Ryan, R. J., Boehner, R. C. and Calder, J. H. 1991: Lithostratigraphic revision of the Upper Carboniferous to Lower Permian strata in the Cumberland Basin, Nova Scotia and the implications for the Maritimes Basin in Atlantic Canada; Canadian Society of Petroleum Geologists Bulletin, v. 39, p. 289-314.

Shanley, K. W., McCabe, P. J. and Hettinger, R. D. 1992: Tidal influence in Cretaceous fluvial strata from Utah, U.S.A: a key to sequence stratigraphic interpretation; Sedimentology, v. 39, p. 905-930.

Scotese C. R. and McKerrow, W. S. 1990: Revised world maps and introduction; *in* Palaeozoic Palaeogeography and Biogeography, eds. W. S. McKerow and C. R. Scotese; Geological Society of London, Memoir No. 12, p. 1-21.

Smith, D. G. 1983: Anastomosed fluvial deposits: modern examples from Western Cananda; *in* Modern and Ancient Fluvial Systems, eds. J. D. Collinson and J. L. Lewin; International Association of Sedimentologists, Special Publication 6, p. 155-168.

Thibaudeau, S. A. and Medioli, F. S. 1986: Carboniferous thecamoebian and marsh foraminifera: new stratigraphic tools for ancient paralic deposits; Geological Society of America, Abstracts with Programs, v. 18, p. 771.

Tye, R. S. and Coleman, J. M. 1989: Depositional process and stratigraphy of fluvially dominated lacustrine deltas: Mississippi Delta plain; Journal of Sedimentary Petrology, v. 59, p. 973-996.

Wanless, H. R. 1964: Local and regional factors in Pennsylvanian cyclic sedimentation; *in* Symposium on Cyclic Sedimentation, ed. D. F. Merriam; Kansas Geological Survey, Bulletin 169, v. 2, p. 593-606.

Wightman, W. G. 1995: Evaluation of microfossil techniques for Phalen Seam roof strata; Energy, Mines and Resources, Canada, Project Report PWGSC File No: 02SQ.23440-4-1218.

Wightman, W. G., Grant, A. C. and Rehill, T. A. 1994a: Paleontological evidence for marine influence during deposition of the Westphalian coal measures in the Gulf of St. Lawrence-Sydney Basin region, Canada; Geological Survey of Canada, Current Research, Paper 1994-D, p. 41-50.

Wightman, W. G., Scott, D. B., Medioli, F. S. and Gibling, M. R. 1993: Carboniferous marsh foraminifera from the coal-bearing strata of the Sydney Basin, Nova Scotia: a new tool for identifying coal-forming environments; Geology, v. 21, p. 631-634.

Wightman, W. G., Scott, D. B., Medioli, F. S. and Gibling, M. R. 1994b: Agglutinated foraminifera and thecamoebians from the Late Carboniferous Sydney Coalfield, Nova Scotia: paleoecology, paleoenvironments and paleogeographical implications; Palaeogeography, Palaeoclimatology, Palaeoecology, v. 106, p. 187-202.

Witzke, B. J. 1990: Paleoclimatic constraints for Paleozoic paleolatitudes of Laurentia and Euramerica; *in* Palaeozoic Paleogeography and Biogeography, eds. W. S. McKerrow and C. R. Scotese; Geological Society of London, Memoir No. 12, p. 57-73.

Wood, J. M. and Hopkins, J. C. 1989: Reservoir sandstone bodies in estuarine valley fill: Lower Cretaceous Glauconitic Member, Little Bow Field, Alberta, Canada; American Association of Petroleum Geologists Bulletin, v. 73, p. 1361-1382.

Yeo, G. M. and Ruixiang, G. 1987: Stellarton Graben: An Upper Carboniferous pull-apart basin in northern Nova Scotia; *in* Sedimentary Basins and Basin Forming Mechanisms, eds. C. Beaumont and A. J. Tankard; Canadian Society of Petroleum Geologists, Memoir 12, p. 299-309.

Mineral Inventory activities for 1998

G. A. O'Reilly and G. J. DeMont

Introduction

During 1998 staff of the Mineral Inventory Program focused their activities in two main areas (Fig. 1): the eastern mainland (O'Reilly) and western Cape Breton Island (DeMont). The program to check mineral deposits in the field and update mineral occurrence information for the eastern mainland region is a continuation of an initiative begun in 1997. This initiative resulted from a recognition that although the Eastern Shore region hosts most of the province's significant gold districts, information on them in the Mineral Occurrence Database is lacking. Program activities in western Cape Breton Island included study of: (1) the Blair River Complex in the northern Cape Breton Highlands; (2) the Mabou Highlands; (3) the Indian Brook - Barachois River area; and (4) examination and sampling of diamond-drill core from the INCO-Scominex gold prospects in the McMillan Flowage area of the central highlands.

Information included in the database during 1998 was publicly released in February 1999 as Version 3 of DP-001b, Mineral Occurrence Database.

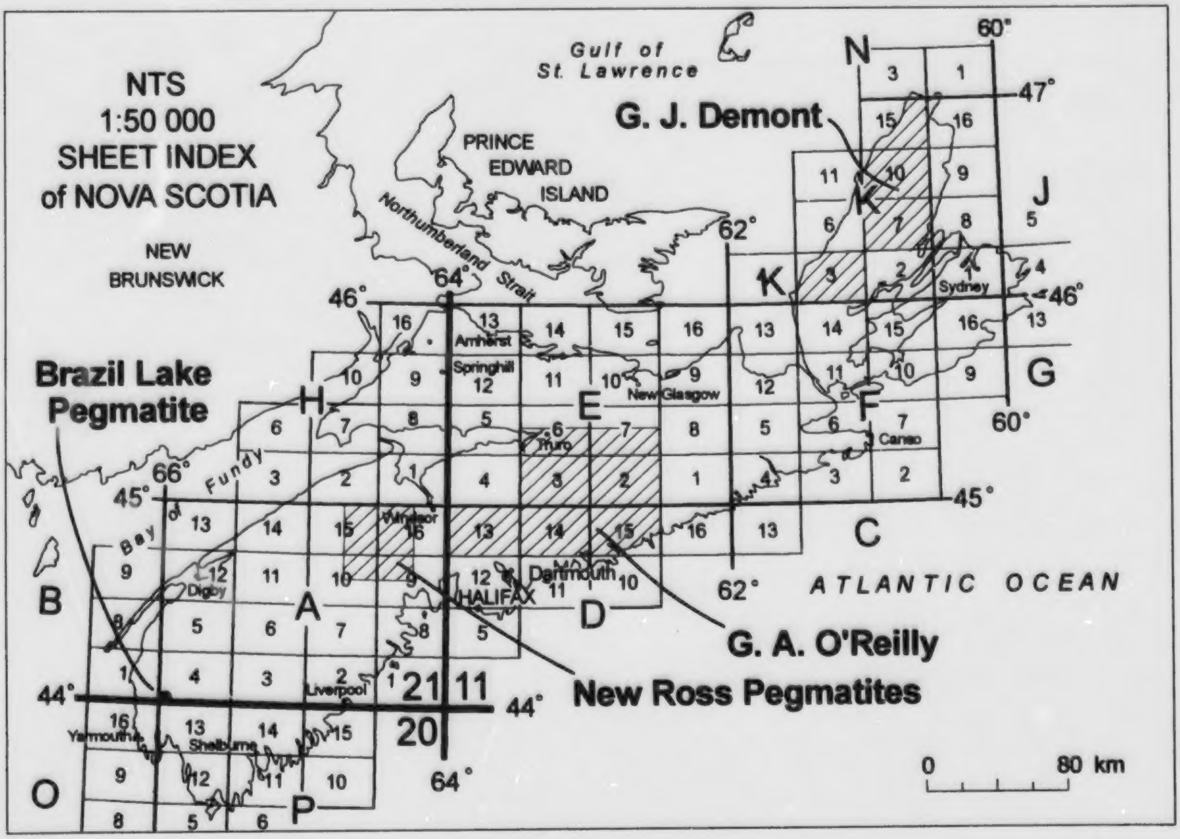

NTS
1:50 000
SHEET INDEX
of NOVA SCOTIA
NEW BRUNSWICK
Gulf of St. Lawrence
PRINCE EDWARD ISLAND
Northumberland Strait
Bay of Fundy
ATLANTIC OCEAN
G. J. Demont
G. A. O'Reilly
Brazil Lake Pegmatite
New Ross Pegmatites
Amherst
Springhill
New Glasgow
Truro
Windsor
Dartmouth
HALIFAX
Digby
Liverpool
Yarmouth
Shelburne
Canso
Sydney
N
K
J
G
F
E
H
C
D
A
B
O
P
21
11
20
60°
47°
46°
62°
64°
45°
66°
44°
0
80 km

Figure 1. NTS index map of Nova Scotia showing areas of Mineral Inventory Program field activities for 1998.

Field Activities

Figure 1 illustrates the NTS map areas in Nova Scotia where mineral occurrences were examined by staff of the Mineral Inventory Program in 1998.

Mainland Mineral Occurrence Investigations

A strong market for tantalum resulted in renewed exploration of our rare-metal pegmatites in southwest Nova Scotia, many of which had never been examined with potential for this metal in mind. During the first part of the field season, field activities on the mainland supported this exploration effort with particular interest being shown in the albite-spodumene pegmatite(s) at Brazil Lake, Yarmouth County, and the columbite-bearing Keddy Mo pegmatite southwest of New Ross, Lunenburg County. In addition to the interest in rare-metal pegmatites, several mineral occurrences in the New Ross area were visited with Sarah Carruzzo, a Ph. D. student from Dalhousie University. These visits were intended to provide her with an overview of the mineral deposits in this area as a starting point for her isotopic and fluid inclusion study of the genesis of granite-hosted mineralization in the South Mountain Batholith.

Most of the remainder of the field season was spent field checking mineral occurrences on NTS map areas 11D/13, 14 and 15, and 11E/02, 03, 06 and 07 (Fig. 1). This area is host to several major gold districts and numerous prospects. In addition to these, the area also hosts several other interesting mineral deposit associations, including: (1) the metasediment-hosted Eastville Zn-Pb prospect within the Goldenville-Halifax Transition Zone over a strike length of some 11 km; (2) barite and/or base metals at several locations between Brookfield and Upper Stewiacke; (3) gold-bearing paleoplacer deposits and occurrences in the Carboniferous Horton Group sediments at Coldstream and Upper Stewiacke; and (4) Pb-Ag-bearing quartz veins in high metamorphic grade gneiss of the Liscomb Complex near Trafalgar.

Cape Breton Field Investigations

Mineral Inventory Program field activities in Cape Breton Island focused on four main areas. The Blair River Complex north of the Cape Breton Highlands National Park is host to the 3.5 million ton Meat Cove Zn deposit. However, mineral exploration throughout that region during the development of the Meat Cove skarn deposit resulted in discovery of about a dozen other mineral occurrences. These sites were field checked during the past season and will be added to the Mineral Occurrence Database. In addition, the industrial mineral potential of anorthosite and syenite units of the Blair River Complex was also examined.

The area between Indian Brook and the Barachois River on the eastern margin of the Cape Breton Highlands hosts several prospects and occurrences of a Au-Ag-Te association. This mineral association is little understood and poorly documented, but has interesting potential. Minerals occur as sulphide-telluride-bearing quartz veins hosted in shear zones, a mineralization style and elemental association comparable to veins mined at the former Franey Mine on Clyburn Brook in Cape Breton Highlands National Park. The Indian Brook-Barachois occurrences were examined in order to compare them with deposits at the former Franey Mine.

Diamond-drill core was examined and sampled from the INCO-Scominex gold prospects in the McMillan Flowage area of the central highlands. These mineral occurrences were added to the Mineral Occurrence Database prior to the 1998 field season. The drill core was sampled to provide thin sections for petrographic examination and for assays to determine elemental levels other than gold. This information will be added to the existing data records.

Several base metal occurrences in the Mabou Highlands were examined in the field. These sites are hosted in Silurian volcanics, and in Carboniferous sediments and marine carbonates of the Windsor Group.

Office Activities

Version 3 of the Mineral Occurrence Database

The Mineral Inventory Program will release Version 3 of DP-001b, Mineral Occurrence Database in February 1999. This release is an upgrade of Version 2 of the database, and includes 104 mineral occurrences not previously in the database as well as information updates to 190 occurrences that were already in the database. With Version 3, the Mineral Occurrence Database now has information on 1164 metallic mineral occurrences and 849 industrial mineral occurrences.

The release of Version 3 also marks a change in Branch policy regarding the Mineral Occurrence Database. Previous releases required that clients purchase the two-disk set containing the updated files. With Version 3, and future releases of the Mineral Occurrence Database, all clients who have purchased earlier versions of the database may obtain the latest version by mailing or bringing in their original data disks and the data files will be updated to the current version free-of-charge.

We also wish to clarify that the Mineral Occurrence Query Program, the computer program used to browse and query the Mineral Occurrence Database, remains as Version 2, DP-001a. Data files in the new release (Version 3) of the Mineral Occurrence Database are completely compatible with Version 2 of the Query Program.

Aggregate Program

G. Prime

Background

Nova Scotia's aggregate resource is an important component of the province's economy. Over the last couple of decades we have seen strong growth in the production and use of aggregate materials, largely reflecting population increases and economic prosperity in the region. Ironically, the factors that have fueled the growth of the aggregate industry have also put pressure on the resource. Issues such as competition for the resource land, land-use conflicts, depletion of reserves, demanding materials specifications, and environmental legislation are increasingly threatening the resource in many parts of the province.

In recognition of growing concerns about this nonrenewable resource, the former Mines and Minerals Branch developed an Aggregate Program in the mid-seventies. Today, its primary goals are: (1) to evaluate the aggregate resource, (2) to assist aggregate producers and communities in meeting their aggregate needs, (3) to promote the wise use of the resource, and (4) to look for new economic opportunities. The program is conducted by one full-time staff member (the author) and a seasonal assistant each year.

The core activity of the Aggregate Program in recent years has been a detailed, systematic examination of the aggregate resource in Nova Scotia on a region-by-region basis. Prioritizing the geographic locations for this research is based on factors such as population base, availability of materials, and anticipated future market demands. The methodology for the program consists primarily of literature research, field investigations, air photo interpretation, and sampling/analytical programs. These regional surveys occasionally lead to more specialized research activities. Examples include diamond-drilling projects for aggregate and dimension stone, and testing aggregate waste fines for agricultural applications.

Another activity which routinely occupies a large portion of time is service to clients. The Minerals and Energy Branch is commonly approached by industry representatives, government agencies, consultants and the general public to provide information on the aggregate resource. Queries can range from locating an aggregate source in proximity to a construction project, to sand for cranberry bogs, to boulder fields for armour stone. Every effort is made to provide the client with the best information available. However, this does not always mean access to information in the form of reports or maps. Many requests involve areas where aggregate maps and reports are not available. For inquiries where published aggregate data are not available we can sit down with the client and discuss the request, using a variety of other data sources or drawing on the geoscientific expertise in the branch. We encourage anyone to use our services and will do our best to meet their needs.

1998 Activities

In 1998 the Aggregate Program focused on field mapping in the western part of the province. This work is part of a continuing study initiated in 1994 to evaluate the aggregate potential in western Nova Scotia. The purpose of the study is to provide a GIS-based digital database and 1:50 000 scale resource maps displaying aggregate deposits, point data, and descriptive fields for each county in the region. The project is being implemented in two phases. The first phase (in progress) will cover the north side of the region or Annapolis Valley area. It comprises Hants, Kings, Annapolis, Digby and Yarmouth Counties. The second phase will cover the south side of the region or South Shore area and consists of Shelburne, Queens and Lunenburg Counties. It is anticipated that the project will take eight years to complete.

The current field season focused on the eastern half of Hants County (Fig. 1), including all of NTS map area 11E/04 and parts of 11E/03, 11E/05, 11E/06 and 11D/13. Field work consisted of an examination of the bedrock and surficial geology in the area for aggregate potential. Many of the exposures examined were located prior to the field season during a preliminary investigation of geological reports and air photos. Others were discovered during the field work, when all navigable roads on an NTS map area were systematically covered. The result was an examination of as many exposures as possible, given the time frame of the field study. This included pits, quarries, road and ditch cuts, railway cuts, stream and shoreline erosional exposures, and excavation sites. Approximately 500 exposures were examined and

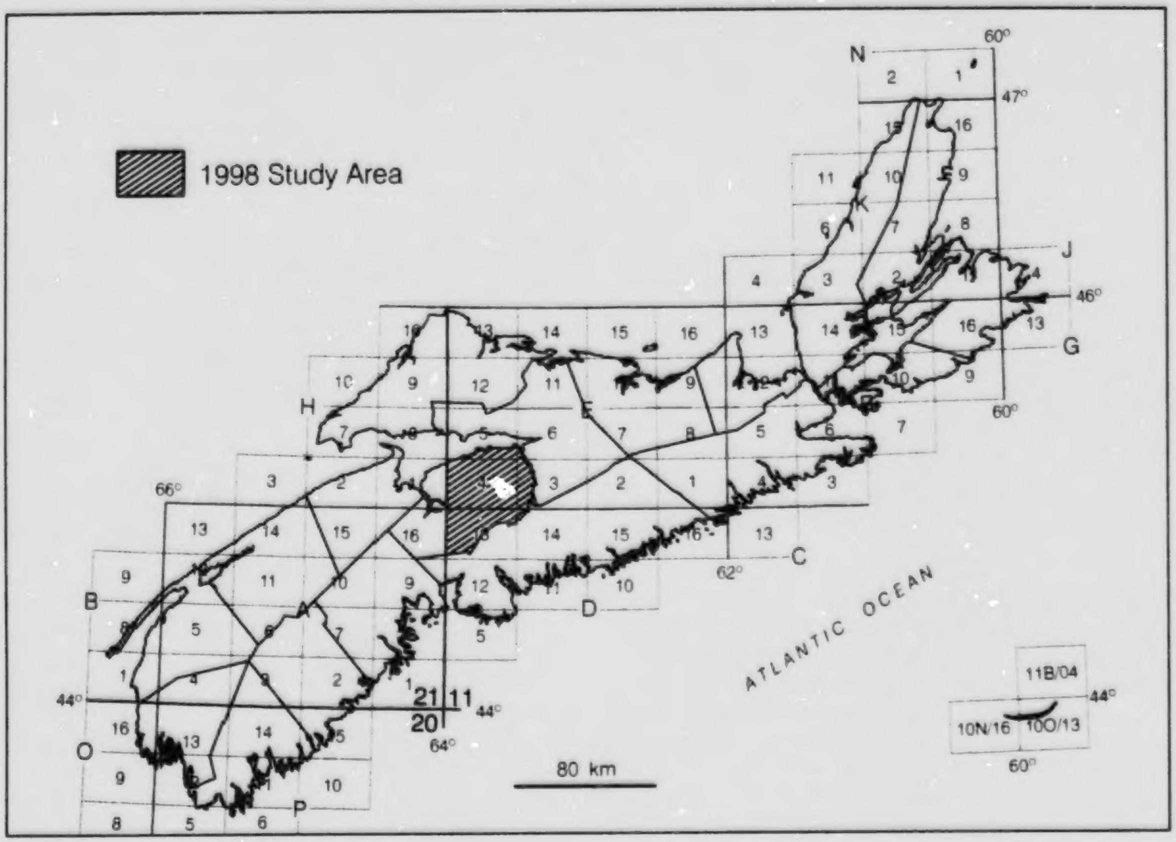


Figure 1. The 1998 field study under the Aggregate Program consisted of NTS Sheets 11E/03, 11E/04, 11E/05, 11E/06 and 11D/13.

described between June 1 and October 10, 1998. A limited sampling program was conducted at selected sites, with samples placed in storage for future aggregate testing. During examination of the bedrock for aggregate purposes, the outcrop was also examined for dimension stone potential. Although not the primary focus of the study, it has been a cost-effective opportunity to examine the geology of the region for other economic possibilities. Depending on the properties of the stone, there may be potential for products such as flagstone, retaining walls, cladding or flooring. Characteristics examined include joint spacing, colour, texture, layering, weathering and competence. The following is a brief discussion of the results of field work in 1998.

Surficial Aggregate Potential

The surficial aggregate potential identified in this study is based on Pleistocene glacial sand and gravel deposits. These glaciofluvial sediments, which were primarily deposited during the melting stages of the last glaciation, are fairly common in eastern Hants County. They consist of ice-contact kame and esker deposits and rare proglacial outwash deposits. Almost all of the occurrences documented have been used in local markets or for private purposes. A small number of new occurrences discovered as part of this study will require follow-up work to assess their potential. Based on field observations, the materials generally appear to contain a moderately high percentage of sedimentary clasts such as sandstone, shale and slate. A small number of the deposits contain unacceptable amounts of pyritic slate clasts. Depending on their proportions, the presence of these deleterious materials can negatively affect the aggregate potential of a granular deposit. The best potential among the glacial deposits appears to be the large sand reserves which still remain in some areas. These materials will continue to be valuable for the metropolitan market, where natural sands are absent.

Bedrock Aggregate Potential

Bedrock in the study area comprises Devono-Carboniferous sedimentary and intrusive rocks and Cambro-Ordivician sedimentary rocks. The Devono-Carboniferous sedimentary rocks consist of sandstone, shale, carbonates and evaporates. They are generally soft and lack durability. The sandstone, shale and carbonates have been used for low-end aggregate products such as fill or for the construction of haulage roads. Shale, in particular, has been used extensively for forest access roads. It is unlikely that any of these sedimentary rocks will produce high quality aggregate. One exception may be a quartzitic sandstone unit which, although not tested to date, appears promising in terms of durability. The primary significance of this unit is its location in an area where aggregate potential is considered low.

The Cambro-Ordivician Meguma Group rocks consist of quartzite and slate. The Goldenville Formation 'quartzite' (an industry term for the more formal rock name 'metagreywacke'), has an excellent reputation as a high quality aggregate and has been produced extensively from a few quarries in the region. The quartzite gets its mechanical strength from metamorphism which caused annealing of the sand grains in the sandstone to produce greater grain-to-grain bond strength. One problem that can occur in this stone is the presence of slate, a material which is considered deleterious for aggregate purposes. Although all Goldenville Formation bedrock contains interbedded slate, only minor percentages are tolerable in high quality aggregate. Predicting the location of quartzite deposits with minimal slate interbeds is severely hampered by poor bedrock exposure in many areas. Therefore, accurately assessing the aggregate potential of the quartzite is not possible without detailed, site-specific work.

The Halifax Formation slate, which is very common in the region, is unsuitable for high quality aggregate. In general, the slate is soft and lacks durability. The competence of the stone appears to reflect the ratio of slate to siltstone present in the bedrock. The presence of interbedded siltstone appears to improve clast strength and resistance to weathering. This probably reflects the fact that siltstone is the fine-grained equivalent of quartzite. The true slate, where the percentage of siltstone is minimal, appears to be very susceptible to water absorption and clast deterioration. Because of its foliation cleavage, slate is easily and economically extracted by ripping. The platy nature of the clasts produced also provides a natural, interlocking support structure when used for applications such as low-traffic haulage roads and the surfacing of driveways. However, all of the slates are typically subject to premature weathering and mechanical wear. An environmental concern in many of the slates in the region is the presence of sulphide minerals which can result in acid drainage problems related to surface runoff.

Devono-Carboniferous granitic rocks, which intrude the Meguma Group sedimentary rocks, are confined to the south side of the study area. Although they apparently have not been extracted for use in the study area, they are being used successfully in other parts of the region. Furthermore, previous studies under the Aggregate Program indicate that these rocks are generally acceptable in producing good quality aggregate. While the intrusives may lack high mechanical strength (LA abrasion loss and petrographic number results are consistently superior in quartzite) they generally pass most aggregate specification tests.

Examination of the study area for dimension stone potential was unsuccessful in identifying any significant new deposits. Some thinly layered sandstones, quartzite with parallel fractures, and slates may be suitable for applications such as retaining walls and flagstone. However, more work is required to establish if there is any economic potential at these locations.

Conclusions

The Annapolis Valley phase of the Western Nova Scotia Aggregate Project is nearing completion. One more year of field work and a clean-up year covering parts of all counties on the northern side of the valley will be required to complete this area. This project has also represented a shift in the way aggregate research is being done under the Aggregate Program. We are now using a global positioning satellite (GPS) receiver and an electronic notebook in the field. The goal for the coming field season is to download the data being gathered in the field into a GIS digital database (ArcView® 3.0) on a daily or weekly basis. This should permit a more efficient and timely delivery of aggregate data in the future. At present, approximately 3000 occurrences have been recorded in the Annapolis Valley region. Of these, 2300 data points have digitally entered into the database. It is anticipated that the first digitally produced maps will be available in the year 2000.

1998 progress report for the Eastern Shore Project

P. K. Smith and L. J. Ham

Background

Over the past 150 years a tremendous wealth of information has been accumulated on the geology and mineral deposits (particularly gold) of the Meguma Terrane in southern Nova Scotia. This information resides primarily: (1) as publications, open files and mineral inventory files at the Nova Scotia Department of Natural Resources and Geological Survey of Canada, (2) in university libraries as research projects and theses, (3) as brochures, papers, journal and various magazine articles and abstracts and, (4) as unpublished data files still residing with numerous research scientists. Because of the continued interest in mineral exploration and the increased need for sound geological information, a compilation and synthesis project was designed to evaluate this information. Two fundamental 'product-driven' results are being sought over the five year duration of this project: (1) new 1:50 000 scale digital geological maps and (2) compilation and synthesis of information on 19 gold deposits having historical production >25,000 oz. Other deposits may also be examined. In addition, the authors will work with the Mineral Inventory group to verify and update all known mineral occurrences in the area.

Scope and Area

This project encompasses all geological and related information, including the compilation and synthesis of mineral deposits along the Eastern Shore. Digital databases will be developed for selected geological, petrographic, whole-rock geochemical and isotopic information and these databases will be made available through departmental publications and GIS services.

The project area is divided into five parts (Fig. 1) with the focus of Year 1 on the most easterly part of the area (east of Longitude 62°00'). This area involves parts of NTS map areas 11F/03, 04, 05 and 06.

1998/99 Work Plan

The work plan for the first year's activities in this area includes:

(1) map compilation of the digital bases and overlay geology,
(2) compilation and verification of all drillhole location data,
(3) geo-referencing of pertinent assessment files in digital form,
(4) location of all mineral deposits and occurrences on the base map,
(5) construction of database files for compilation of Forest Hill, Isaac's Harbour, Lower Seal Harbour, Upper Seal Harbour and Wine Harbour gold districts, and
(6) synthesis of mineral deposits.

Status

Currently, the project is running slightly behind schedule due to previous time commitments to other work. The following is a brief summary, in point form, of the current status. (1) The initial digital base map and geology compilation for the area is complete with minor editing and checking still required. (2) Verification of drillhole locations based on original files is complete. (3) The digital outlines of relevant assessment file locations are complete with required editing. (4) Mineral deposit locations are not yet entered on the map; however, this information will be compiled in the near future with the aid of information in the abandoned mines database. (5) Databases for individual mineral deposits are being compiled. (6) Synthesis of mineral deposits has not yet started.

Although the project is behind, it is felt that significant advances will be made in the upcoming fiscal year.

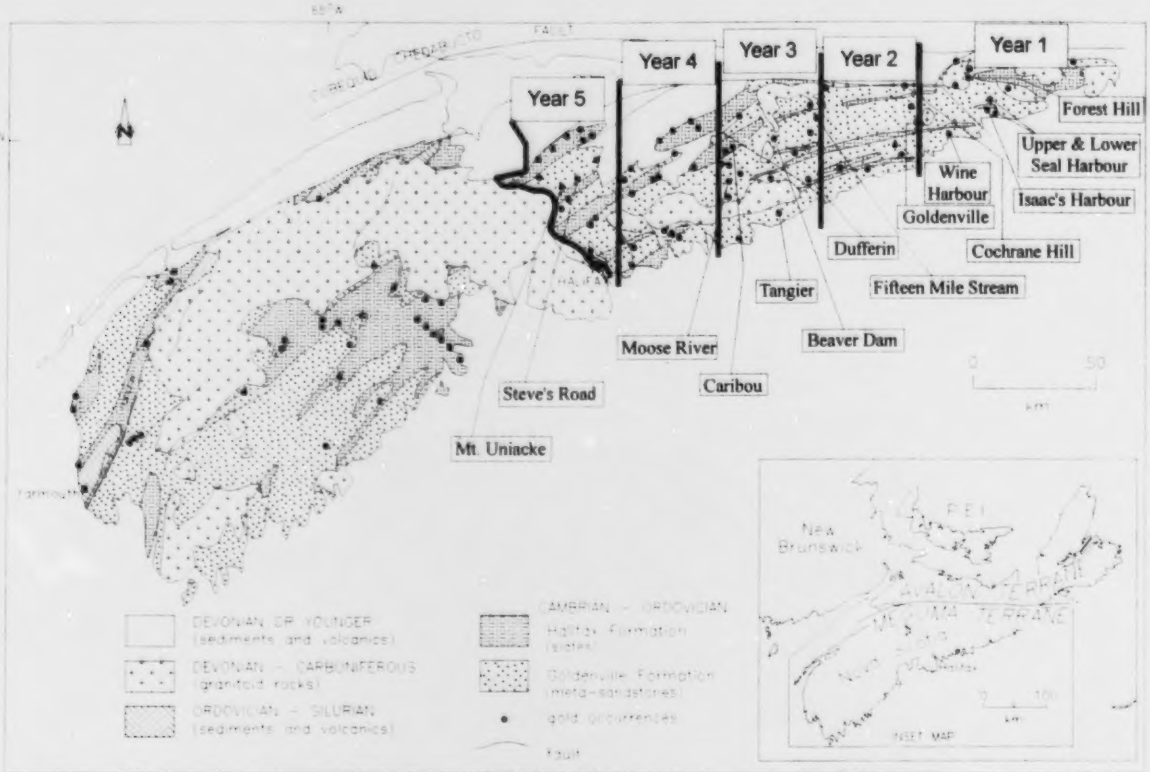

Year 5
Year 4
Year 3
Year 2
Year 1
Forest Hill
Upper & Lower Seal Harbour
Isaac's Harbour
Wine Harbour
Goldenville
Cochrane Hill
Dufferin
Fifteen Mile Stream
Tangier
Beaver Dam
Moose River
Caribou
Steve's Road
Mt. Uniacke
HALIFAX
COBEQUID - CHEDABUCTO FAULT
N
0 50
km
New Brunswick
P.E.I.
AVALON TERRANE
MEGUMA TERRANE
INSET MAP
0 100
km
DEVONIAN OR YOUNGER (sediments and volcanics)
DEVONIAN - CARBONIFEROUS (granitoid rocks)
ORDOVICIAN - SILURIAN (sediments and volcanics)
CAMBRIAN - ORDOVICIAN
Halifax Formation (slates)
Goldenville Formation (meta-sandstones)
gold occurrences
fault

Figure 1. Simplified geological map of the Meguma Terrane in Nova Scotia showing the planned progress of the Eastern Shore Project and former gold districts.

Mapping and 3-dimensional stratigraphic modelling of unconsolidated Mesozoic and Cenozoic deposits in Nova Scotia: plans for the new millennium

R. R. Stea

The topography of Nova Scotia started to take shape during the last stages of the breakup of Pangaea in the late Mesozoic, when a thick cover of Cretaceous fluvial sediments was uplifted and faulted. This exhumation cycle continued through the Tertiary and resulted in hills of Paleozoic or older rocks, and valleys filled with pre-tectonic Cretaceous deposits and post-tectonic Quaternary sediments. During the Quaternary, ice sheets further eroded the highland areas and preferentially deposited till sheets and meltwater sediments in lowland areas. Glacial lakes formed repeatedly, before and after glacial advances. Nova Scotia is one of the few places in the world that has a distinctive sedimentation record of a globally-significant climatic event that occurred at the end of the last glaciation (Younger Dryas).

Little is known about the stratigraphy and architecture of the unconsolidated Mesozoic and Cenozoic sediments in these lowland areas, blanketed by glacial till. How extensive are the buried Cretaceous sediments and are Tertiary sediments preserved in hidden valleys? How many glaciations are recorded in the Quaternary sequence, and what are their ages? Geological mapping is essential to answer these important scientific questions. The Geoscience Needs Workshop (Voluntary Planning, 1996), a two-day meeting of geoscience stakeholders in Nova Scotia, identified surficial mapping as a high priority for the division.

Nova Scotia has a patchwork coverage of surficial maps at different scales and styles, produced for different purposes. Surface mapping is incomplete in some areas, and a comprehensive look at the Mesozoic and Cenozoic subsurface deposits has only been completed in a few areas of deep surficial cover. Mapping efforts will be modelled after a 3-dimensional pilot mapping project just completed in the Carboniferous Lowlands of central Nova Scotia (NTS sheet 11E/03, Fig. 1), which has provided tangible benefits to the economy of Nova Scotia as well as advancing geological knowledge. The discovery of large, hidden Mesozoic basins formerly thought to be isolated, small outliers resulted in a staking rush and a multi-million dollar kaolin exploration program. Several confined aquifers within the buried basins are presently being evaluated by a groundwater company as a water supply for the town of Shubenacadie. A glacial lake of Younger Dryas age was discovered in central Nova Scotia, which may be host to valuable brick clays and aggregate deposits.

It is the goal of the surficial mapping group to produce 1:50 000 scale maps in three high priority areas of Nova Scotia, based on the age of existing coverage and the thickness of drift cover. These areas include the (1) Central Lowlands and Annapolis Valley, (2) southwest Nova Scotia, and (3) Cape Breton Island.

At present we are working on NTS map area 11E/04 (Fig. 1), and intend to finish the adjacent map sheets within the next few years. Mapping consists of road, stream and coastline traverses, guided by air photograph interpretation and digital elevation imagery. Water-well logs and old diamond-drill hole records are checked for accuracy and location. Seismic reflection test spreads will be done at sites where subsurface information is minimal and seismic reflection profiles can provide the details of basin architecture across suspected deep drift basins and buried valleys.

Selected deep drift sites defined on the basis of this information need to be drilled, logged and sampled. Drillholes should be cased and analyzed using down-hole geophysics to supplement the stratigraphic information obtained through coring. Aquifer characteristics can also be obtained at certain drill sites.

Representative samples of the mapped surficial deposits are obtained and analyzed for a variety of physical and chemical properties, including: (1) grain size, (2) lithology (pebble counts), (3) till geochemistry (regional or detailed sampling), (4) geotechnical and hydrological properties (e.g. hydraulic conductivity, Atterberg limits), (5) aggregate properties (e.g. abrasion tests, petrographic number), and (6) economic testing (e.g. refractory clay firing properties).

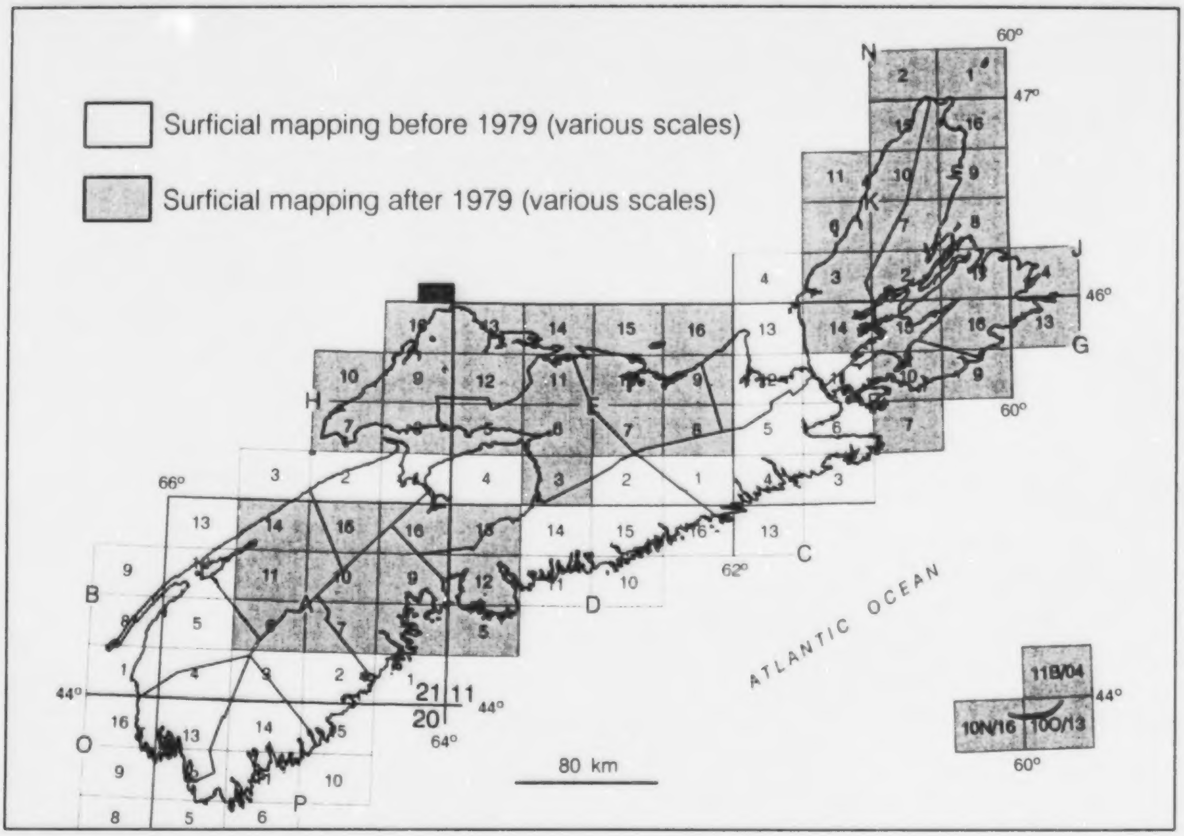

Surficial mapping before 1979 (various scales)
Surficial mapping after 1979 (various scales)
ATLANTIC OCEAN
80 km
60°
47°
46°
44°
62°
64°
66°
N
K
J
G
H
E
F
B
A
C
D
O
P
21
11
20
11E/04
10N/16
10O/13

Figure 1. NTS index map of Nova Scotia showing coverage of surficial geological mapping.

The outputs will be AutoCad®-generated digital and hard-copy colour surficial maps, and an ArcInfo®-ArcView® compatible, fully interactive digital database of sediment properties, site descriptions, stratigraphic sections, photographs, core logs, and seismic test spreads and profiles. This will be designed after the digital 1:500 000 surficial map of Nova Scotia (Stea *et al.*, 1992). A digital and hard-copy report will accompany each map, describing the map units, sediment properties, stratigraphy, and inferred geological events.

The completed maps and database with common formats will provide baseline data for pipeline construction, aggregate resource evaluation, agriculture, and mineral exploration. The integrated geological and geophysical approach to stratigraphic mapping of surficial deposits can be used as a model for the exploration of buried valleys in other areas of Maritime Canada.

In 1999, and into the 21st century, the objectives of the surficial mapping group will be as follow.

(1) Production of a new series of colour surficial geological maps for Nova Scotia at a scale of 1:50 000. Surface mapping will involve the integration of digital elevation models and radarsat imagery with traditional aerial photography and field methods.

(2) Mapping and 3-dimensional stratigraphic modelling of unconsolidated Mesozoic and Cenozoic surficial materials, primarily found in lowland areas of deep drift. The methods employed will be; (a) seismic reflection profiling; (b) compilation of water well-logs, diamond-drill holes, geotechnical drilling and other stratigraphic databases; and (c) new diamond-drilling and auguring.

(3) Compilation of a fully interactive surficial geology database (GIS-ArcInfo®) including the mapping information, subsurface stratigraphy, section and sample site descriptions (colour photos, section schematics; radiocarbon dates and paleo-ecological data), grain-size, geotechnical properties, hydrogeological data and

geochemistry of surficial materials, individual map sheet reports, and a summary report on the surficial geology.

This is admittedly a wish-list and budgetary contraints will define how much of this work gets done. We are presently trying to fund this mapping program through the National Mapping Initiative (NATMAP) and are also looking for alternative sources of funding through private enterprise.

References

Stea, R. R, Conley, H. and Brown, Y. 1992: Surficial geology map of the Province of Nova Scotia; Nova Scotia Department of Mines and Energy, Map 92-3, scale 1:500 000.

Voluntary Planning 1996: Nova Scotia geoscience needs workshop: a summary of focus group discussions; workshop co-sponsored by the Nova Scotia Department of Natural Resources and the Geological Survey of Canada, May 13-14, 1996, 37 p.

Geology of the Guysborough - Mulgrave - L'Ardoise area: a progress report[1]

C. E. White and S. M. Barr[2]

Introduction

Mapping in the area between Lochaber Lake in northern mainland Nova Scotia and Loch Lomond in southern Cape Breton Island (parts of NTS sheets 11E/08, 11F/05, 06, 10, 11, 12 and 15) (Fig. 1) was begun in 1995. This project follows up on work done by Cormier (1994) in the area west of Guysborough, and by Smith (1980, 1981) in the area northeast of Guysborough. The purpose of the project is to better define rock units, stratigraphy, and the igneous, metamorphic, and structural history in the area providing an improved basis for evaluation of economic resource potential. This paper provides an overview of the results of the project to date, and outlines the additional work planned to tackle some of the unresolved geological problems. A preliminary map of the area has been published (White and Barr, 1998); in so far as possible, the terminology adopted for rock units follows the work of Smith (1980, 1981, and cited in more detail *in* Williams *et al.*, 1985).

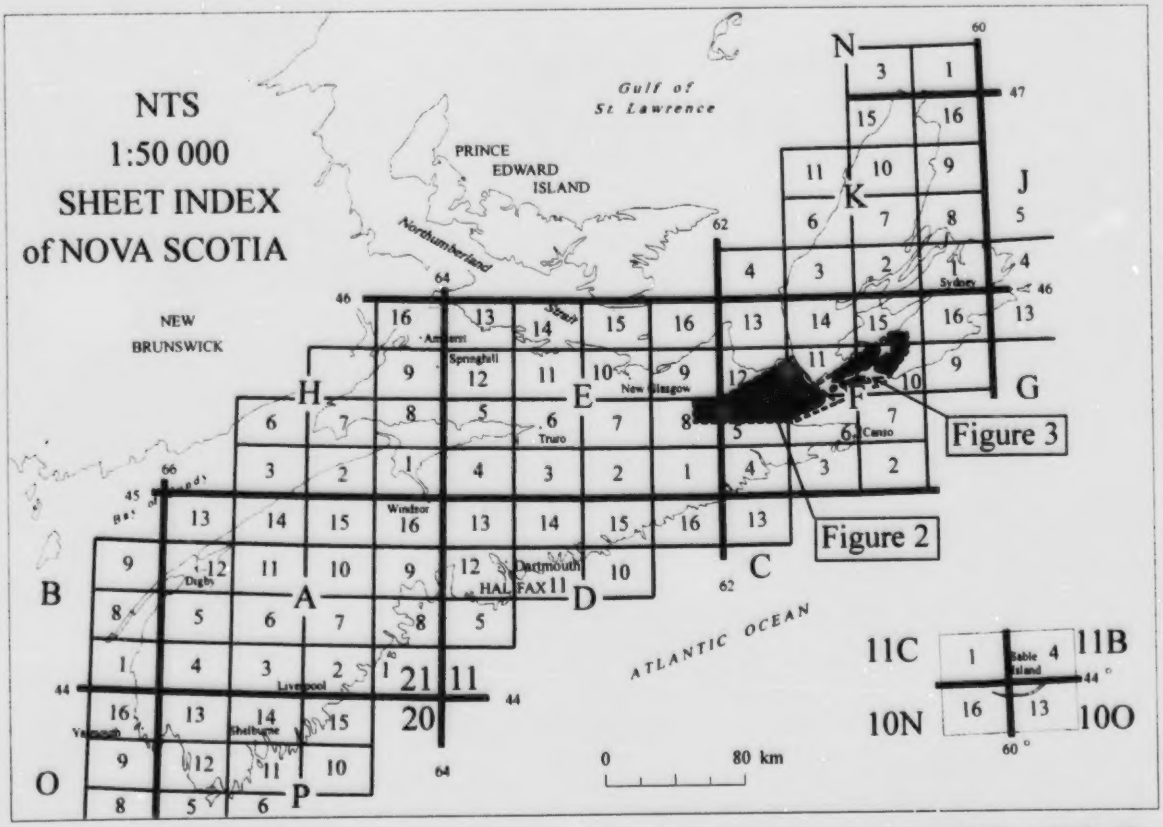

NTS
1:50 000
SHEET INDEX
of NOVA SCOTIA
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Gulf of St Lawrence
Northumberland Strait
ATLANTIC OCEAN
Amherst
Springhill
New Glasgow
Truro
Windsor
Dartmouth
HALIFAX
Digby
Liverpool
Shelburne
Yarmouth
Sydney
Canso
Sable Island
A
B
C
D
E
F
G
H
J
K
N
O
P
11C
11B
10N
10O
21
20
11
Figure 2
Figure 3
44
45
46
47
60
62
64
66
0
80 km

Figure 1. NTS index map for Nova Scotia showing the location of the mapped area (parts of 11E/08, 11F/05, 06, 10, 11, 12 and 15).

---

[1] Funding (1995-1997) from Natural Sciences and Engineering Research Council research grants to S.M. Barr.

[2] Geology Department, Acadia University, Wolfville, Nova Scotia B0P 1X0

Map Units

Guysborough Group

Introduction

A significant result of this project has been the recognition that the area located between the Chedabucto-Guysborough County Fault system in the south and the Roman Valley Fault in the north and extending through the southernmost part of Cape Breton Island, here termed the Guysborough block, is underlain by Middle Devonian volcanic and sedimentary rocks (Fig. 2). These rocks are referred to as the Guysborough Group, and preliminary subdivision includes five formations. The age of the Guysborough Group is constrained by a U-Pb (zircon) age of 389 ± 2 Ma for a rhyolitic tuff (Cormier *et al.*,1995) in the Hoppenderry Formation (see below), and a U-Pb (zircon and baddeleyite) age of 385 ± 2 Ma for the Erinville gabbro (Cormier *et al.*, 1995), which intruded the Roman Valley Formation (see below).

The Guysborough Group is in faulted contact with Carboniferous sedimentary rocks of the Horton Group on the north and west. On the south, the Guysborough Group is complexly truncated by the Chedabucto, Guysborough County, and subsidiary faults, which separate the group from faulted slivers of varied metamorphic rocks of uncertain age, metasedimentary rocks of the Meguma Terrane (Hill, 1987, 1991), and Carboniferous sedimentary rocks of the Horton Group in the St. Marys Basin (Murphy and Rice, 1998).

Minister Brook Formation

The Minister Brook Formation appears to be the oldest unit of the Guysborough Group and is exposed in the central part of the Guysborough block (Fig. 2). It consists of: (1) light grey, thickly bedded, feldspathic greywacke to quartzwacke interlayered with dark grey, laminated siltstone, and (2) slate with brown-grey, thickly bedded, medium grained subarkose beds. Rare, grey, massive to faintly bedded, quartz arenite beds occur throughout the formation, as well as thin (<10 cm) beds or lenses of dark grey to black, clast-supported conglomerate. Clasts (<2 cm in diameter) include quartz arenite and other intraformational sedimentary rocks. Along the faulted southern margin of the formation, small lenses of dark grey to green, amygdaloidal to massive basalt are locally interlayered with black, basaltic, lithic lapilli tuff.

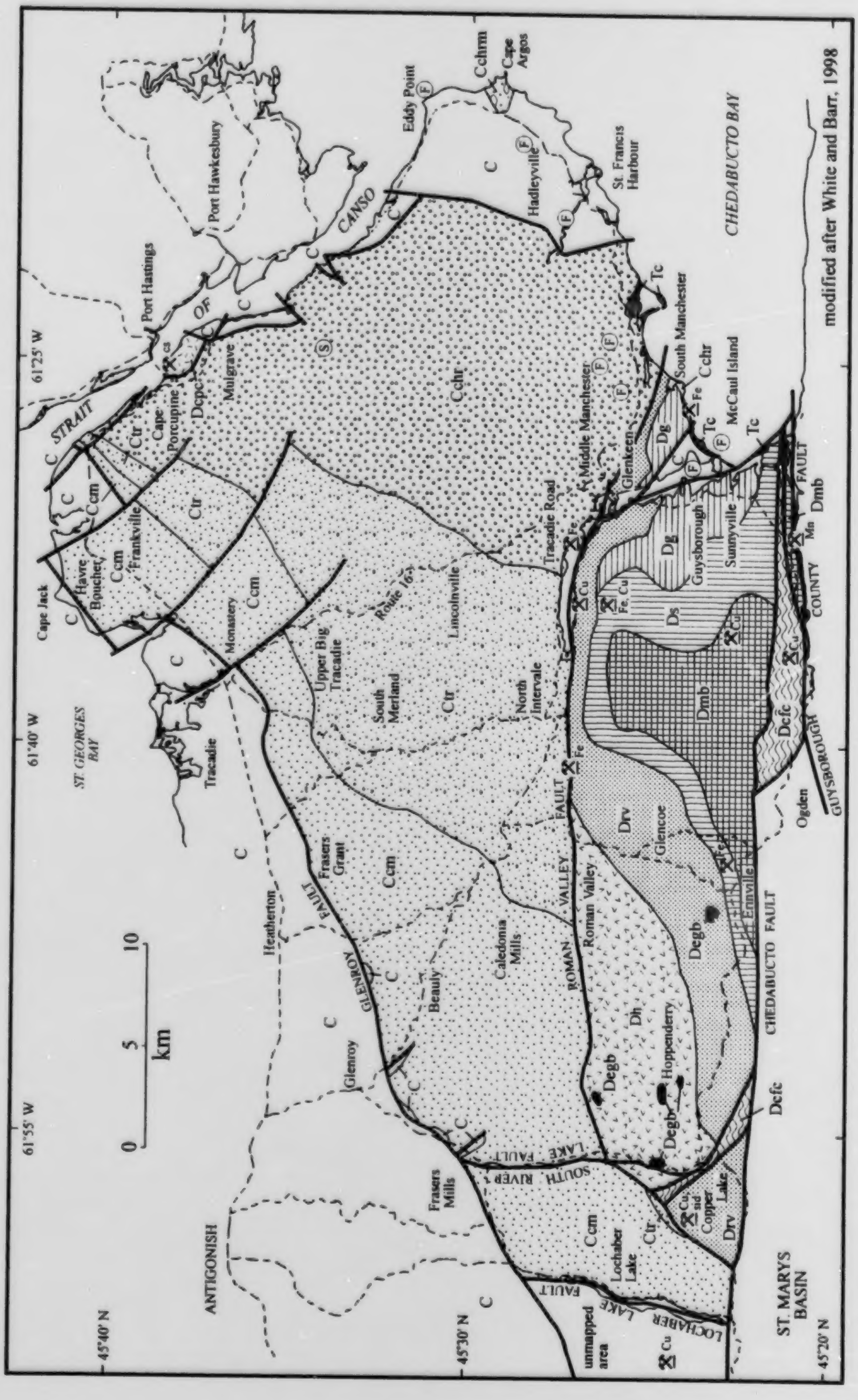
Sunnyville Formation

The name Sunnyville Formation (Mooney, 1990; Cormier *et al.*, 1995) is retained for a distinct package of volcanic and sedimentary rocks within the Guysborough block. The mainly sedimentary part of the formation is in gradational contact with the underlying Minister Brook Formation. These rocks consist of mainly maroon to grey, polymictic pebble conglomerate interlayered with minor maroon to red-brown subarkose and sublitharenite and minor basalt and basaltic tuff. The conglomerate is typically well indurated, poorly sorted, immature, and matrix supported. Clasts are predominantly sedimentary, with minor basalt and rhyolite. Subarkose and sublitharenite layers (<2 m thick) are typically of limited lateral extent, are massive to well bedded, and locally display trough cross-stratification and ripple marks. Rare grey to dark green basaltic flows (5-10 m thick) are associated with dark grey to black basaltic lithic lapilli tuff.

The mainly volcanic unit of the Sunnyville Formation consists of dark maroon to grey basalt and andesite flows interlayered with minor maroon to grey polymictic breccia and conglomerate and maroon to grey-green siltstone. The flows are typically fine- to medium-grained, vary from massive to amygdaloidal, and locally contain plagioclase phenocrysts. Amygdaloidal flow tops and peperitic textures are common, indicating extrusion on a muddy substrate. The breccia and conglomerate are poorly sorted and vary from matrix to clast supported. Large clasts are predominantly composed of basalt and chert, whereas the matrix consists of volcanic and sedimentary clasts and broken plagioclase crystals. These rocks probably represent reworked mafic lithic lapilli tuff.

Glenkeen Formation

The Glenkeen Formation (Smith, 1980, 1981; Williams *et al.*,1985) is a mainly conglomeratic unit that overlies the Sunnyville Formation in the Guysborough area and also forms most of southern Isle Madame and Petit-de-Grat Island (Fig. 3). Smith (1980, 1981; Williams *et al.*, 1985) assigned the formation to the Horton Group and suggested the presence of an angular unconformity between the Glenkeen and Sunnyville formations. However, observations during the present study suggest that the two formations are conformable and that the Glenkeen Formation is part of the Guysborough Group.


61°55' W
61°40' W
61°25' W
45°40' N
45°30' N
45°20' N
0
5
10
km
ANTIGONISH
ST. GEORGES BAY
STRAIT OF CANSO
CHEDABUCTO BAY
ST. MARYS BASIN
unmapped area
Cape Jack
Havre Boucher
Frankville
Monastery
Tracadie
Upper Big Tracadie
South Merland
Lincolnville
North Intervale
Tracadie Road
Middle Manchester
Glenkeen
South Manchester
McCaul Island
Guysborough
Sunnyville
Ogden
Glencoe
Erinville
Roman Valley
Hoppenderry
Copper Lake
Lochaber Lake
Frasers Mills
Glenroy
Beauly
Caledonia Mills
Frasers Grant
Heatherton
Cape Porcupine
Mulgrave
Port Hastings
Port Hawkesbury
Eddy Point
Cape Argos
Hadleyville
St. Francis Harbour
Route 16
GLENROY FAULT
ROMAN VALLEY FAULT
CHEDABUCTO FAULT
SOUTH RIVER LAKE FAULT
LOCHABER LAKE FAULT
GUYSBOROUGH COUNTY FAULT
C
Ccm
Ctr
Cchr
Cchrm
Dcpc
Dg
Ds
Dmb
Drv
Dh
Degb
Defc
Tc
Cu
Fe
Mn
sid
cs
F
S

modified after White and Barr, 1998

Figure 2. Simplified geological map of the western part of the mapped area, northern mainland Nova Scotia.

Legend For Figures 2 and 3

TRIASSIC

- ▩ *CHEDABUCTO FORMATION* (Tc)

CARBONIFEROUS

- □ WINDSOR AND CANSO GROUPS (C)
- ■ ST. PETERS GABBRO (Cspgb)

HORTON GROUP

- ▨ *CALEDONIA MILLS FORMATION* (Ccm)
- ▨ *TRACADIE ROAD FORMATION* (Ctr)
- ▨ *CLAM HARBOUR RIVER FORMATION* (undivided) (Cchr)
- ▨ *CLAM HARBOUR RIVER FORMATION* (upper) (Cchru)
- ▨ *CLAM HARBOUR RIVER FORMATION* (middle) (Cchrm)
- ▨ *CLAM HARBOUR RIVER FORMATION* (lower) (Cchrl)

DEVONIAN

- ■ ERINVILLE AND OTHER GABBROS (Degb)

GUYSBOROUGH GROUP

- ▨ *HOPPENDERRY FORMATION* (Dh)
- ▨ *ROMAN VALLEY FORMATION* (Drv)
- ▤ *GLENKEEN FORMATION* (Dg)
- ▥ *SUNNYVILLE FORMATION* (Ds)
- ▦ *MINISTER BROOK FORMATION* (Dmb)

DEVONIAN or OLDER

- ▨ PETIT-DE-GRAT GRANITE (Dpg)
- ▨ CAPE PORCUPINE COMPLEX (Dcpc)
- ▨ CHEDABUCTO FAULT COMPLEX (Dcfc)

Symbols

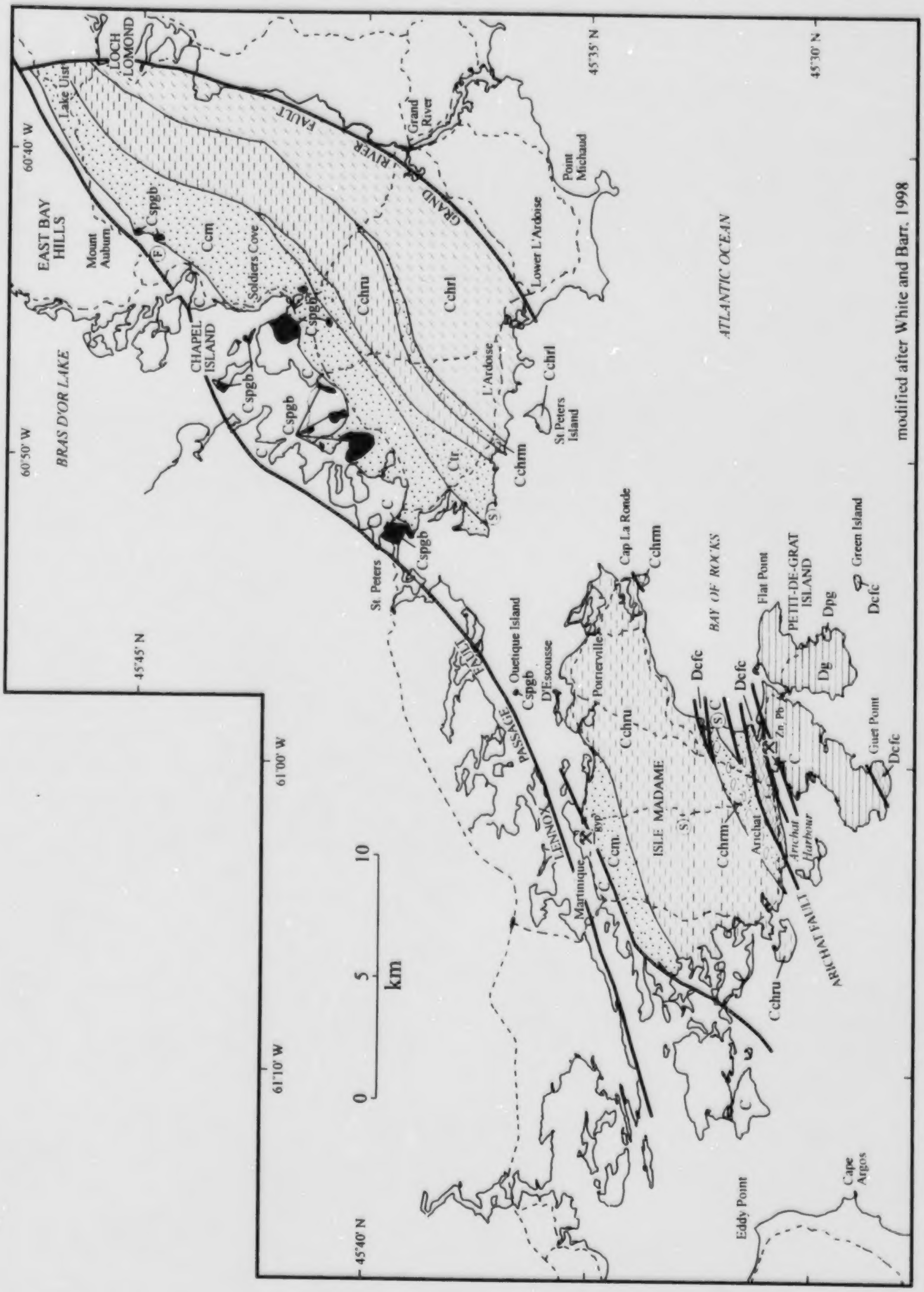
Geological contact .... —

Fault .... —

Fossil locality .... Ⓕ

Spore locality .... Ⓢ

Mine or quarry (abandoned, active)
Fe: iron, Pb: lead, Zn: zinc, Cu: copper,
Mn: manganese, sid: siderite,
cs: crushed stone, gyp: gypsum .... ⚒$_{Fe}$ ⚒$_{Fe}$


60°40' W
60°50' W
61°00' W
61°10' W
45°35' N
45°30' N
45°45' N
45°40' N
0
5
10
km
EAST BAY HILLS
BRAS D'OR LAKE
Mount Auburn
Lake Uist
LOCH LOMOND
GRAND RIVER FAULT
Grand River
Point Michaud
Lower L'Ardoise
L'Ardoise
Soldiers Cove
CHAPEL ISLAND
St Peters Island
St. Peters
Ouetique Island
D'Escousse
LENNOX PASSAGE FAULT
Martinique
Poirtervile
ISLE MADAME
Cap La Ronde
BAY OF ROCKS
Flat Point
PETIT-DE-GRAT ISLAND
Green Island
Guet Point
Arichat
Arichat Harbour
ARICHAT FAULT
ATLANTIC OCEAN
Eddy Point
Cape Argos
Cspgb
Ccm
Cchru
Cchrl
Cchrm
Ctr
C
Defc
Dpg
Dg
Zn, Pb
gyp
(S)
(E)

modified after White and Barr, 1998

Figure 3. Simplified geological map of the eastern part of the mapped area, southern Cape Breton Island.

The Glenkeen Formation consists mainly of polymictic, well indurated conglomerate. In the Guysborough area, the formation is predominantly a maroon to grey, massive, immature, poorly sorted, typically matrix supported pebble- to cobble-conglomerate. Clasts consist mainly of basalt, with subordinate red quartz arenite and siltstone. On Petit-de-Grat Island the formation is grey to red, contains cobble- to locally boulder-size clasts, typically massive, poorly- to well-sorted, and clast supported. Clasts are predominantly composed of red felsic volcanic rocks, quartzite and siltstone, with rare andesitic clasts; however, toward the north quartzite clasts predominate.

In both areas, the conglomerate is interlayered with minor maroon subarkose and maroon to grey siltstone. Also present are red and purple volcanogenic breccia and conglomerate, similar to those in the Sunnyville Formation, and associated dark grey, coarse grained, tuffaceous sandstone, rare, dark grey, basaltic flows (<5 m thick), and lithic lapilli tuff.

Roman Valley Formation

The Roman Valley Formation underlies much of the northern part of the Guysborough block. Cormier (1994) included these rocks within the Clam Harbour River Formation of Smith (1980, 1981; Williams *et al.*, 1985). However, this unit includes volcanic members and the sedimentary rocks are lithologically distinct from the Clam Harbour River Formation (described below), and hence the new name Roman Valley Formation is assigned here. Contacts between the Roman Valley Formation and the Sunnyville and Glenkeen formations are not exposed; however, the sandstone varieties in the Roman Valley Formation are similar to those in the underlying formations, suggesting that the relationship is gradational.

The Roman Valley Formation is subdivided into three units (too small to show on Figure 2). One unit consists mainly of black to dark grey, well-laminated siltstone and slate, similar to those in the Minister Brook Formation. The slate weathers rust-brown where pyrite nodules are present. The siltstone and slate are interlayered with thin (<5 cm wide), light grey quartz wacke and minor dark grey oligomictic pebble conglomerate lenses. Clasts in the conglomerate consist predominantly of quartz arenite. Near contacts with the Erinville gabbro, the siltstone and slate are contact metamorphosed and spotted hornfels is common. Minor basaltic lithic lapilli tuff occurs in the siltstone/slate unit in the Glencoe area. The unit pinches out to the east where it becomes interbedded with the quartz arenite unit. The siltstone/slate unit is host to the Copper Lake Cu-siderite deposit.

A second unit consists of grey, massive to well-laminated, quartz arenite to subarkose interlayered with weakly laminated, quartz wacke and feldspathic greywacke. The rocks are typically fine grained, and bedded on a scale of 10s of centimetres; cross-stratification, ripple marks, and graded bedding are locally preserved. Minor, thin (<5 cm), grey, well-laminated siltstone and slate are common throughout the unit. Pyrite locally occurs in slate beds as thin (<2 mm thick) stringers parallel to bedding planes. Thin (<1 cm), brown to orange dolomitic lenses and beds were observed in the northern part of the unit.

The third unit consists of brown to orange, polymictic pebble conglomerate, quartz arenite, and quartz wacke interlayered with grey to green laminated siltstone. The conglomerate is massive, well indurated, poorly sorted, and typically matrix supported. Clasts are mainly sedimentary in origin, with minor basalt and rare granodiorite fragments. The quartz arenite is fine grained, weakly laminated, and forms thin (<20 cm thick) layers. Minor, grey basalt flows (5-20 m thick), lithic lapilli tuff, and rare, coarse grained, well-laminated, tuffaceous sandstone are interlayered with the conglomerate.

Hoppenderry Formation

The Hoppenderry Formation occurs in the western part of the Guysborough block, and is subdivided into four units (too small to show on Figure 2) which include: (1) a rhyolitic unit, (2) a basaltic unit, (3) a conglomeratic unit, and (4) a quartz arenite unit. The rhyolitic unit includes both rhyolite flows and welded tuff. Flows are buff to purple, locally flow banded and spherulitic, and quartz-feldspar phyric. Associated pyroclastic rocks include rhyolitic lithic crystal and lithic crystal vitric lapilli tuff. The former ranges from dark grey to buff to purple, and displays well-developed layering and flow-banding. The vitric tuff is massive, pale green, and consists of a glassy matrix of shards with quartz and anorthoclase grains.

The basaltic unit includes flows with minor interlayered lithic lapilli tuff and rare green-grey siltstone. The basaltic flows are dark to light green, fine grained, and massive to amygdaloidal. The basalts are tholeiitic and both basalts and rhyolites apparently formed in a continental within-plate rift setting (Cormier *et al.*, 1995).

The conglomeratic unit is predominantly orange, polymictic, pebble- to cobble-conglomerate. The conglomerate is immature, well indurated, poorly sorted, and matrix supported, and contains clasts of quartzite, siltstone, tuff and granite. Basaltic flows and tuffs are locally interlayered with the conglomerate and appear identical to those in the underlying basaltic unit.

The quartz arenite unit consists mainly of grey, massive to well-laminated quartz arenite and quartz wacke, interlayered with grey to green, laminated siltstone, slate, and rare basaltic lithic lapilli tuff and thin (<1 cm wide), brown dolomitic beds.

Gabbroic Rocks

Gabbroic dykes and sills, generally <5 m wide, are common in all formations of the Guysborough Group. In addition, small gabbroic plutons occur at scattered locations throughout the Guysborough block. The gabbroic rocks range from dark green to black, and from fine- to coarse-grained. They display intergranular to subophitic textures, and consist mainly of plagioclase and clinopyroxene (augite), and accessory amounts of opaque phases, apatite and titanite. The gabbro pluton west of Hoppenderry contains up to 30% forsteritic olivine. The Erinville gabbro contains abundant apatite (3%) compared to the other gabbros. Drill core from the Erinville gabbro indicates that it becomes increasingly anorthositic with depth (Cormier, 1994; Dickie, 1989).

Horton Group

Introduction

The area north of the Guysborough block is assigned to the Horton Group based on lithological similarities to Horton Group strata in the St. Marys Basin (Murphy and Rice, 1998) and western Cape Breton Island (e.g. Giles *et al.*, 1997) and sparse palynological evidence (White and Barr, 1998). The group is divided into three northeastward-trending formations that young toward the northwest (Figs. 2, 3).

Clam Harbour River Formation

The Clam Harbour River Formation underlies a large area between the Roman Valley Fault and the Strait of Canso (Fig. 2), as well as in the Isle Madame-Loch Lomond area (Fig. 3). In southern Cape Breton Island, the formation is subdivided into three units, but an equivalent subdivision cannot yet be made in the mainland part of the formation. Smith (*in* Williams *et al.*, 1985) recognized two formations in the area northeast of Guysborough, but our mapping is not yet sufficiently detailed to make such a subdivision. The formation was intruded by rare, narrow (<5 m wide), mafic dykes. It appears to be broadly equivalent to the Creignish Formation of the Horton Group in western Cape Breton Island (Williams *et al.*, 1985).

The lower unit of the Clam Harbour River Formation is well exposed along the coast south of L'Ardoise (Fig. 3). The rocks are in faulted contact with mainly Neoproterozoic rocks to the southeast (Barr *et al.*, 1996) and hence the base is not exposed. This unit consists predominantly of light grey to white quartz arenite interlayered with minor black laminated siltstone, shale and conglomerate. The quartz arenite forms layers up to 5 m thick and is typically medium- to coarse-grained and massive, although it is locally well laminated and cross-stratified, and contains abundant quartz veins. The black laminated siltstone and shale layers are typically 2-5 m thick and contain thin (<5 cm wide), fine grained quartz arenite beds and lenses, as well as rare, thin (<1 cm thick), cream coloured limy layers. Slump folds and crosslaminations are locally preserved in these fine grained quartz arenite interbeds. Thin (10-20 cm thick) beds or lenses of matrix-supported, poorly indurated, grey, polymictic pebble conglomerate also occur in the quartz arenite. Clasts are generally up to 2 cm in diameter and are intraformational, composed of black shale and quartz arenite.

The middle unit of the Clam Harbour River Formation is narrow (<1500 m thick), and extends from Cape Argos through Isle Madame to north of L'Ardoise (Figs. 2, 3). It is in sharp, but conformable contact with the underlying quartz arenite unit, and consists predominantly of red to grey massive polymictic boulder conglomerate/breccia, locally interlayered with grey quartz arenite and red arkose and siltstone. The conglomerate/breccia is poorly indurated, clast to matrix supported, and poorly sorted. Clasts include quartzite and siltstone, with subordinate rhyolite, basalt, granite and diorite. On Isle Madame, clasts include amphibolite and mylonite and in this area the unit may have originally, unconformably, overlain the Chedabucto Fault Complex (see below). The quartz arenite and arkose/siltstone layers are 0.5-5 m thick, massive to laminated, and commonly display graded bedding and cross-stratification.

The upper unit of the Clam Harbour River Formation consists of light grey to green to maroon quartz arenite and siltstone interlayered with grey to black laminated siltstone. The quartz arenite (1-5 m thick) is fine- to coarse-grained, typically laminated, and locally cross-stratified and rippled. Carbonized plant remains are rare. The black laminated siltstone is locally interlayered with thin (<2 cm thick) quartz arenite and rare dolomitic lenses. On Isle Madame, polymictic pebble to boulder conglomerate is commonly interlayered with the arenite and siltstone. The conglomerate is maroon to grey and closely resembles conglomerate in the middle part of the formation.

Tracadie Road Formation

The Tracadie Road Formation (Smith *in* Williams *et al.*, 1985) is predominantly siltstone and is well exposed along Route 16. It is interpreted to be broadly equivalent to the lower (Strathlorne) part of the Strathlorne-Ainslie Formation of the Horton Group in western Cape Breton Island (Williams *et al.*,1985). The formation is mainly grey to black laminated siltstone interlayered with light grey, fine- to coarse-grained quartz arenite layers (2 cm to 2 m in thickness). Brown dolomitic lenses and beds, <2 cm thick, are common, and polymictic pebble conglomerate layers, <50 cm thick, are a minor component. The conglomerate is matrix supported and moderately well indurated and sorted. It contains clasts of quartzite, siltstone, and other sedimentary lithologies. The quartz arenite layers are more abundant and thicker toward the base of the formation, and the contact with the underlying Clam Harbour River Formation is gradational.

Caledonia Mills Formation

The Caledonia Mills Formation is a new name suggested for a previously unnamed sequence of rocks that gradationally overlies the Tracadie Road Formation. The formation appears to be equivalent to the upper (Ainslie) part of the Strathlorne-Ainslie Formation of the Horton Group in western Cape Breton Island (Williams *et al.*, 1985). East of St. Peters (Fig. 3), the formation has been intruded by minor, narrow (5 m wide), mafic dykes probably related to the St. Peters gabbro (Barr *et al.*, 1994).

The Caledonia Mills Formation consists predominantly of red to maroon siltstone and arkose, with less abundant quartz arenite, conglomerate and limestone. The siltstone contains abundant detrital muscovite, and locally has small, grey reduction spots. Arkosic units are fine- to medium-grained, locally well laminated and cross-stratified, and form beds up to 0.5 m thick. Grey, massive to well laminated, fine grained quartz arenite, forming layers up to 5 m wide, is interbedded with the siltstone and may contain abundant plant fragments. Rare, light grey limestone lenses and grey polymictic conglomerate also occur locally. These conglomerates are well indurated, vary from grey to red, and contain volcanic, sedimentary, and may contain granitic clasts. Grey to green laminated siltstone is locally interlayered with the red to maroon siltstone.

St. Peters Gabbro, Minor Basalt, and Mafic Dykes and Sills

Small bodies of gabbro, minor basalt, and related dykes and sills occur in the St. Peters area. Their age is well constrained by U-Pb dating at 339 ± 1 Ma (Barr *et al.*, 1994), so they appear to have been intruded more or less after deposition of the Horton Group and before the Windsor Group. Plagioclase and clinopyroxene predominate, with minor amphibole, biotite, and accessory phases. Their chemical characteristics suggest that they are tholeiitic and formed in a continental within-plate tectonic setting (Barr *et al.*,1994).

Windsor and Canso Groups

The Windsor and Canso groups occur mainly around the fringes of the mapped area, in faulted or unconformable contacts with the units described above. They generally consist of red, green and grey siltstone interbedded with sandstone, shale and mudstone. Carbonized plant remains are locally quite abundant. Well-laminated grey limestone, massive fossiliferous limestone, and gypsum are minor components.

Locally, areas of Macumber Formation, the lowest member of the Windsor Group, occur on the northwestern margin of the mapped area southeast of the Glenroy Fault. These areas consist of grey, laminated, locally fossiliferous limestones that lie conformably on redbeds (Boehner and Giles, 1993) which we assign to the Caledonia Mills Formation.

Triassic Rocks

Small areas of Triassic strata occur east of Guysborough, and were informally termed the Chedabucto Formation by Tanner (1997). They consist of red to brown, polymictic pebble to cobble conglomerate, sandstone and shale. The conglomerate is typically poorly indurated, poorly sorted, matrix supported, and includes volcanic, sedimentary and plutonic clasts. The sandstone is fine- to medium-grained and consists predominantly of arkose. Cross-stratification and grey reduction spots are common. Vertebrate fossils occur in strata northeast of McCaul Island (Stevenson, 1964). Contacts with older rocks are angular unconformities or faults.

Metamorphic and Granitic Rocks

Chedabucto Fault Complex

Varied metamorphic rocks that occur in a zone broadly associated with the Chedabucto and subsidiary faults are here grouped together as the Chedabucto Fault Complex. They occur in the area southwest of Hoppenderry in the western part of the mapped area, in a narrow belt between the Chedabucto and Guysborough County faults, and on Isle Madame and Green Island. Although contacts between these rocks and adjacent units are not exposed, it is clear that they have been faulted into their present positions. The belt between the Chedabucto and Guysborough County faults is mainly composed of strongly laminated and foliated phyllonite, but includes at least one area of garnet sillimanite schist. In thin section, micas in the phyllonite show extreme parallelism, and pressure shadows occur around quartz grains. The garnet sillimanite schist contains fine grained quartz, red-brown biotite, sillimanite and garnet, with bands and lenses of disaggregated quartz, oriented parallel to the foliation. The western fault-bounded area consists of mylonitic amphibolite and sheared granitoid rocks. On Isle Madame and Green Island, amphibolite predominates, with minor areas of garnet sillimanite schist, chlorite schist, quartzite, basalt, and granitic mylonite (Barr *et al.*, 1992).

The ages of these varied rocks are uncertain. Amphibole from amphibolite on Green Island yielded a Devonian $^{40}Ar/^{39}Ar$ cooling age of ca. 391 ± 4 Ma (Keppie, 1982). Similar types of rocks are exposed, west of the mapped area, along the Cobequid-Chedabucto Fault system in the Melrose area (Edmonds, 1990) and at Clarke Head; the latter have yielded Devonian U-Pb and Carboniferous $^{40}Ar/^{39}Ar$ dates (Gibbons *et al.*, 1996).

Cape Porcupine Complex

In the Cape Porcupine area, on the Strait of Canso, coarse grained granite, with minor granodiorite and diorite and mafic dykes, occur in association with mylonitic and phyllonitic rocks (Barr *et al.*, 1992). The mylonitic rocks include granite and probable metasedimentary lithologies, whereas the phyllonites are metasedimentary and contain abundant muscovite and biotite. Minor brecciated tuffaceous(?) rocks are also present. The complex occurs in faulted contact with the Clam Harbour River Formation. A sample from the granitic part of the complex is being dated by the U-Pb (zircon) method to try to resolve the age of this assemblage.

Petit-de-Grat Granite

The Petit-de-Grat Granite is a small body located on the southeastern tip of Petit-de-Grat Island. A smaller body of similar granite occurs to the west near Guet Point on Isle Madame (not shown on map because of scale). The granite produced a contact metamorphic aureole in the adjacent Glenkeen Formation, which in that area includes mafic volcanic rocks and dykes that were previously included in the Fourchu Group (Weeks, 1964). The petrochemistry of the granite was described by Barr *et al.* (1982), who inferred a Carboniferous age based on Rb-Sr dating.

Structural Features

Introduction

Within the mapped area two structural domains with contrasting structural geometries and histories are recognized. Domain I includes the sedimentary and volcanic rocks of the Devonian Guysborough Group on mainland Nova Scotia (Fig. 4). They are typically unmetamorphosed, although locally reach chlorite grade of greenschist facies metamorphism. Domain II includes rocks and structures related to the Carboniferous Horton Group, which have been further subdivided into smaller domains in order to define the character of regional-scale structures.

Domain I

Based on the distribution of map units, Cormier (1994) interpreted the Guysborough Group to have been folded into a regional northeastward-plunging anticlinal fold that was refolded about an east-west trending fold axis. However, poles to bedding form a broad girdle of points (Fig. 4a) defining a shallow northeastward-plunging fold axis (044/34) and poles to cleavage (Fig. 4a) form a cluster with an average cleavage that strikes northeast and is steep (045/90). These data suggest that the structures observed in the Guysborough Group are related to one episode of deformation. The deformation in this area may have been related to dextral movements along the bounding faults which resulted in the development of a positive flower structure (Webster, 1996; Webster *et al.*, 1998).

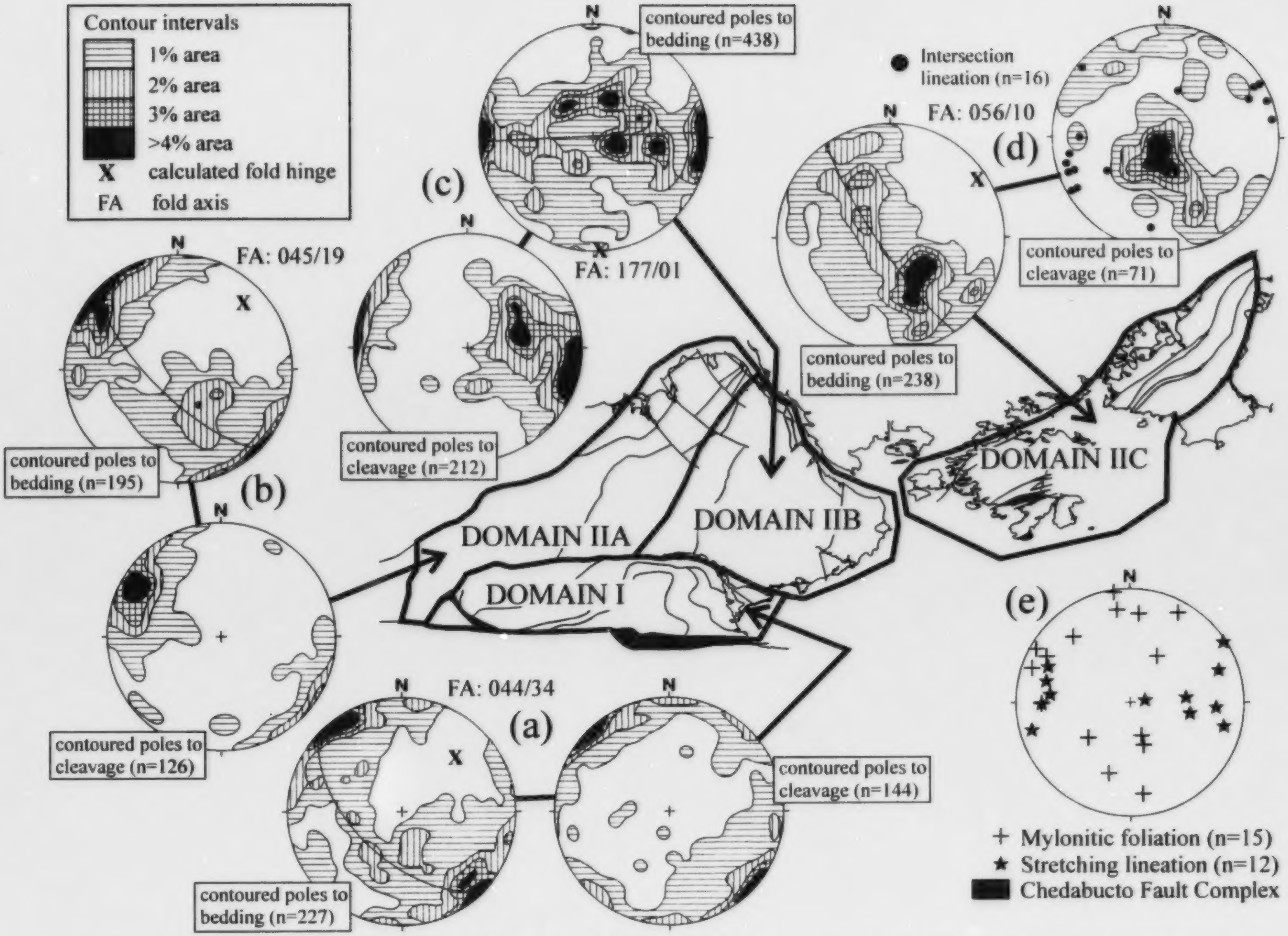

Contour intervals
1% area
2% area
3% area
>4% area
X calculated fold hinge
FA fold axis
N
FA: 045/19
X
contoured poles to bedding (n=195)
(b)
N
contoured poles to cleavage (n=126)
(c)
N
contoured poles to bedding (n=438)
FA: 177/01
X
N
contoured poles to cleavage (n=212)
Intersection lineation (n=16)
N
FA: 056/10
(d)
X
N
contoured poles to cleavage (n=71)
contoured poles to bedding (n=238)
DOMAIN IIA
DOMAIN IIB
DOMAIN IIC
DOMAIN I
N
FA: 044/34
(a)
X
N
contoured poles to bedding (n=227)
contoured poles to cleavage (n=144)
(e)
N
+ Mylonitic foliation (n=15)
★ Stretching lineation (n=12)
Chedabucto Fault Complex

Figure 4. Summary of structural data from the mapped area, northern mainland Nova Scotia and southern Cape Breton Island. (a) Domain I, Guysborough Group; (b) Domain IIA, Horton Group (western); (c) Domain IIB, Horton Group (central); (d) Domain IIC, Horton Group (eastern); (e) Chedabucto Fault Complex.

Domain II

Domain II (Horton Group) occupies the area north of the Guysborough Group and has been subdivided into three smaller subareas (Fig. 4). Domain IIA (Fig. 4b) is the most westerly part of Domain II and is characterized by open to tight, upright to slightly inclined folds with a moderately developed axial planar cleavage. Poles to bedding form a girdle distribution with shallow northeastward-plunging fold axis (045/19). Poles to cleavage form a well-defined cluster with an average cleavage that strikes north-northeast and dips steeply to the southeast (036/78SE).

Domain IIB (Fig. 4c) is to the east of Domain IIA and is characterized by tight to close, upright, subhorizontal folds with a weakly to locally strongly developed axial planar cleavage. In contrast to Domain IIA, folds in Domain IIB are north-south trending. Poles to bedding define an east-west-trending girdle with a very shallow southward plunging fold axis (177/01). Poles to cleavage are more scattered, but still indicate northward-striking, steeply- to moderately-westward dipping features.

Domain IIC (Fig. 4d) is the most easterly part of Domain II and extends from Isle Madame to Loch Lomond. In the L'Ardoise-Loch Lomond area exposed folds are typically isoclinal and recumbent with a prominent subhorizontal cleavage and a shallow northeast-southwest intersection lineation whereas on Isle Madame folds are open upright structures with a poorly developed cleavage. Poles to bedding form a girdle distribution about a shallow northeastward plunging axis (056/10). Poles to cleavage form a well-defined cluster indicative of a subhorizontal feature.

Faults

The most significant faults in the mapped area are the east-west-trending dextral Chedabucto and Roman Valley faults (Fig. 2) that are part of the Minas Fault system (Webster, 1996; Webster *et al.*, 1998). Splays from this fault system bound the Glenkeen Formation on Petit-de-Grat Island (Fig. 3) where mylonitic foliation are generally anastomosing with variable dips (Fig. 4e) and shallow east-west-plunging stretching lineations. Other major faults trend northeast, such as the Glenroy, Lennox Passage, and Grand River faults (Figs. 2, 3). Less major faults trending northwest are common along the northernmost part of northern mainland, and offset the Glenroy Fault (Fig. 2). Northward-trending faults in the westernmost part of the mapped area locally contain mylonitic textures (e.g. Lochaber Lake Fault of Murphy *et al.*, 1991 and South River Lake Fault).

Economic Geology

Minor metallic mineral showings occur throughout the mapped area. Specular hematite commonly occurs on fractures and in veins throughout the area, but is especially abundant in rocks of the Guysborough Group. Specular hematite was mined from a large vein near South Manchester (Stevenson, 1964) and from smaller veins throughout the Guysborough block (Nova Scotia Mineral Occurrence Database). Locally specular hematite is associated with chalcopyrite. Lead and zinc minerals were mined in Windsor limestone near Arichat Harbour (Weeks, 1964), and gypsum was quarried near Lennox (Collins, 1962). Chalcopyrite and siderite were mined from veins near Copper Lake in the Roman Valley Formation (e.g. MacDonald, 1937), and siderite veins are also common in the Tracadie Road Formation. Copper and manganese occur in phyllonite of the Chedabucto Fault Complex near the Chedabucto Fault (Hill, 1991).

Gabbro bodies near Erinville and South River Lake have been quarried for 'black granite' (Dickie, 1989). Granite at Cape Porcupine is quarried for crushed stone (Graves, 1990).

Conclusions

The Guysborough-Mulgrave-L'Ardoise mapping project has led to a new perspective on the geology in this area of limited previous geological investigation. However, further mapping is planned to verify the distribution and contact relations among units in the Guysborough and Horton groups. For example, subdivision of the Clam Harbour River Formation in the area between the Roman Valley Fault and the Strait of Canso should be possible with more detailed mapping. Formalization of unit names and establishment of type sections is required, and additional age control and more detailed structural studies are needed to resolve stratigraphic uncertainties in the Horton Group, and to compare the formations to those established in the St. Marys Basin (Murphy and Rice, 1998) and in western Cape Breton Island (Giles *et al.*, 1997). The extent of the units defined in this study in the area west of Lochaber Lake will be investigated, and is of particular importance because of copper mineralization in this area (e.g. Benson, 1974). Lithologies of clasts in conglomeratic units in both the Guysborough and Horton groups will be examined to establish provenance, as done by Murphy and Rice (1998).

Additional geochemical studies will be done to assess stratigraphic variations in volcanic rock composition in the Guysborough Group, and petrologic studies of the mylonitic amphibolitic and granitic lithologies within the Chedabucto Fault Complex will be done to determine the origin and tectonic setting of these units.

Acknowledgments

We thank Peter Giles, Bob Boehner, Bob Ryan and Paul Smith for the many helpful discussions of the geological relationships of northern mainland Nova Scotia and southern Cape Breton Island. Rob Naylor is thanked for numerous discussions regarding the sedimentological and stratigraphic aspects of the Horton Group. We also thank Rick Horne for his helpful review of this paper, and editor, Kathy Mills for her helpful suggestions.

References

Barr, S. M., O'Reilly, G. A. and O'Beirne, A. M. 1982: Geology and geochemistry of selected granitoid plutons of Cape Breton Island; Nova Scotia Department of Mines and Energy, Paper 82-1.

Barr, S. M., White, C. E. and Graves, M. 1992: Meguma Terrane in southern Cape Breton Island?; Atlantic Geology, v. 28, p. 194.

Barr, S. M., Grammatikopoulos, A. L. and Dunning, G. R. 1994: Early Carboniferous gabbro and basalt in the St. Peters area, southern Cape Breton Island, Nova Scotia: Atlantic Geology, v. 30, p. 247-258.

Barr, S. M., White, C. E. and Macdonald, A. S. 1996: Stratigraphy, tectonic setting, and geological history of Late Precambrian volcanic-sedimentary-plutonic belts in southeastern Cape Breton Island, Nova Scotia; Geological Survey of Canada, Bulletin 468.

Benson, D. G. 1974: Geology of the Antigonish Highlands; Geological Survey of Canada, Memoir 376.

Boehner, R. C. and Giles, P. S. 1993: Geology of the Antigonish Basin, Antigonish County, Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branches, Memoir 8.

Collins, G. A. 1962: Arichat map area, 11F/11E, Richmond-Inverness counties, Nova Scotia, Canada; Geological Survey of Canada, Open File 18.

Cormier, C. F. M. 1994: Field relations, petrology, and age of volcanic and associated sedimentary and gabbroic rocks in the Guysborough area, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Cormier, C. F. M., Barr, S. M. and Dunning, G. R. 1995: Geological setting, petrology, and age of volcanic and gabbroic rocks in the Guysborough area, Nova Scotia; Atlantic Geology, v. 31, p. 153-166.

Dickie, G. B. 1989: Building stone project; *in* Mines and Minerals Branch, Report of Activities 1989, Part A, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Mines and Energy, Report 89-3, p. 31.

Edmonds, S. L. 1990: Petrology of dioritic and gneissic rocks in the Melrose area, eastern Nova Scotia; B.Sc. honours thesis, Acadia University, Wolfville, Nova Scotia.

Gibbons, W., Doig, R., Gordon, T., Murphy, J. B., Reynolds, P. and White, J. C. 1996: Mylonite to megabreccia: tracking fault events within a transcurrent terrane boundary in Nova Scotia, Canada; Geology, v. 24, p. 411-414.

Giles, P. S., Hein, F. J. and Allen, T. L. 1997: Bedrock geology of Margaree (11K/06), Cape Breton Island, Nova Scotia; Geological Survey of Canada, Open File 3254, scale 1:50 000, map with marginal notes.

Graves, M. 1990: Geology and lithological correlation of Cape Porcupine, Aulds Cove, Guysborough County, Nova Scotia; Atlantic Geology, v. 26, p. 171.

Hill, J. D. 1987: Geology of the Guysborough-Country Harbour area, Nova Scotia; *in* Current Research, Part A; Geological Survey of Canada, Paper 87-1A, p. 415-422.

Hill, J. D. 1991: Petrology, tectonic significance and economic potential of Devonian peraluminous granitoid plutons in the Canso and Forest Hill areas, Eastern Meguma Terrane, Nova Scotia; Geological Survey of Canada, Bulletin 383.

Keppie, J. D. 1982: The Minas Geofracture; *in* Major Structural Zones and Faults of the Northern Appalachians, eds. P. St-Julien and J. Beland; Geological Association of Canada, Special Paper 24, p. 263-280.

MacDonald, D. F. 1937: Final report on the Copper Lake prospect and the Lochaber copper prospect, Antigonish

County, Nova Scotia; Nova Scotia Department of Mines, Assessment Report 13-B-11(01).

Mooney, S. 1990: Stratigraphy of two late Paleozoic basins: implications for the timing of final emplacement of the Meguma Terrane; M.Sc. thesis, Lakehead University, Thunder Bay, Ontario.

Murphy, J. B., Keppie, J. D. and Hynes, A. J. 1991: The geology of the Antigonish Highlands, Nova Scotia; Geological Survey of Canada, Paper 89-10.

Murphy, J. B. and Rice, R. J. 1998: Stratigraphy and depositional environment of the Horton Group in the St. Marys Basin, central mainland Nova Scotia; Atlantic Geology, v. 34, p. 1-25.

Smith, P. K. 1980: Geology of the Guysborough area, Guysborough County, Nova Scotia; *in* Mineral Resources Division, Report of Activities 1979, ed. K. A. McMillan; Nova Scotia Department of Mines and Energy, Report 80-1, p. 109.

Smith, P. K. 1981: Horton Group stratigraphy in the Guysborough area, Nova Scotia; *in* Mineral Resources Division, Report of Activities 1980, ed. K. A. Mills; Nova Scotia Department of Mines and Energy, Report 81-1, p. 37.

Stevenson, I. M. 1964: Geology, Chedabucto Bay, Nova Scotia; Geological Survey of Canada, Map 1156A, scale 1:63 360.

Tanner, L. H. 1997: The Chedabucto Formation: Evidence for a Mesozoic "broad terrain" in the Canadian Maritimes; *in* Geological Society of America, Abstracts with Programs, v. 29, p. 84.

Webster, T. L. 1996: Integrated GIS and geological study of the St. Mary's Graben and adjacent areas, northern Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Webster, T. L., Murphy, J. B. and Barr, S. M. 1998: Anatomy of a terrane boundary: an integrated structural, geographic information system, and remote sensing study of the late Paleozoic Avalon-Meguma Terrane boundary, mainland Nova Scotia, Canada; Canadian Journal of Earth Sciences, v. 35, p. 787-801.

Weeks, F. J. 1964: Geology, St. Peters, Richmond County, Cape Breton Island, Nova Scotia; Geological Survey of Canada, Map 1083A, scale 1:63 360.

White, C. E. and Barr, S. M. 1998: Preliminary geological map of Guysborough, Richmond and Antigonish counties (parts of NTS sheets 11E/08, 11F/05, 11F/06, 11F/10, 11F/11, 11F/12 and 11F/15), Nova Scotia, Canada; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Open File Map 1998-001, scale 1:100 000.

Williams, G. L., Fyffe, L. R., Wardle, R. J., Colman-Sadd, S. P. and Boehner, R. C. 1985: Lexicon of Canadian Stratigraphy, Volume VI, Atlantic Region.

Preliminary bedrock geology of the Digby map sheet (21A/12), southwestern Nova Scotia

C. E. White, R. J. Horne, C. Muir and J. Hunter

Introduction

Southwestern Nova Scotia (i.e. Digby-Yarmouth-Shelburne area) is underlain by three principal rock assemblages: (1) Cambrian-Early Devonian metasedimentary and metavolcanic rocks, (2) mainly Late Devonian granitoid rocks, and (3) Mesozoic sedimentary and volcanic rocks (Fig. 1a). The Cambrian-Early Devonian metamorphic sequence and Devonian granitoid rocks are the characteristic units of the Meguma Terrane (Williams, 1979; Williams and Hatcher, 1983) (Fig. 1a). The metamorphic rocks were deformed and metamorphosed during the Acadian Orogeny, resulting in regional-scale folds and associated cleavage (Keppie, 1993). The age of deformation is constrained by ^{40}Ar/^{39}Ar age data at ca. 400-385 Ma (e.g. Muecke *et al.*, 1988; Hicks *et al.*, in press). Although granitoid rocks truncate regional fold structures, they are interpreted to be late syntectonic (e.g. Benn *et al.*, 1997). Middle Carboniferous deformation related to regional shear zones is recognized in the Yarmouth to Meteghan area, where it affects the metamorphic rocks (Culshaw and Liesa, 1997). Mesozoic sedimentary and volcanic rocks overlap older rocks with angular unconformity.

Southwestern Nova Scotia has been previously mapped on a reconnaissance scale (1:126 720) by Taylor (1967, 1969). Geological maps at 1:50 000 scale exist for the eastern part of NTS sheet 21A/12 (Smitheringale, 1973), the South Mountain Batholith (MacDonald, 1994) and the Shelburne area (Rogers, 1986). For the majority of the metasedimentary and metavolcanic rocks, however, no 1:50 000 scale geological maps are available for southwestern Nova Scotia, and published maps date back to those of Taylor (1967, 1969).

The results presented in this report represent the first stage of a five-year program of geological mapping in southwestern Nova Scotia, including parts of NTS sheets 21A/04, 05, 12; 21B/01, 08, 09; 20O/09, 16; and 20P/11, 12, 13, 14 (Fig. 1b). The principal goals of this project are to produce a series of 1:50 000 scale geological maps of the area, to describe and interpret the sedimentary, igneous, metamorphic, and deformational history of the Cambrian-Early Devonian metamorphic rocks, and to evaluate the economic potential of the area.

Geological mapping of the bedrock geology of the Digby area (NTS sheet 21A/12, Fig. 1) was completed during the summer of 1998. Mapping was undertaken at 1:10 000 scale, using orthophoto maps and colour air photos as base maps. The results have been digitally recorded using FieldLog® and AutoCAD® and plotted on 1:10 000 digital base maps, and a 1:50 000 scale compilation map has been generated. Over 400 samples have been collected from the area, including samples of Doyle (1979) and Mahoney (1996), which are on loan from the Geology Department of Acadia University, Wolfville. All samples were slabbed and about 200 were examined in thin section. Mineral occurrences of significance were verified in the field and new occurrences were also appropriately documented and sampled.

This report presents a summary of the results and conclusions from these studies, with emphasis on map units (stratigraphy), field relations and structural geology.

Map Units

Introduction

Taylor (1965, 1969) and Smitheringale (1973) subdivided the rocks in the present mapped area into formal units on the basis of lithology, paleontology, and comparison with similar lithologies elsewhere in Nova Scotia (e.g. Crosby, 1962). Metamorphic rocks include the Cambrian to Ordovician Meguma Group, consisting of the lower Goldenville Formation and the upper Halifax Formation, the Silurian White Rock Formation and the Early Devonian Torbrook Formation. Recently Schenk (1995a) elevated the Meguma Group to the rank of supergroup and elevated the Goldenville and Halifax formations to group status. Similarly, Schenk (1995b) combined the White Rock and Torbrook formations into the Annapolis Supergroup and elevated the formations to the rank of groups. All of these units were recognized during the present study; however, the traditional unit names

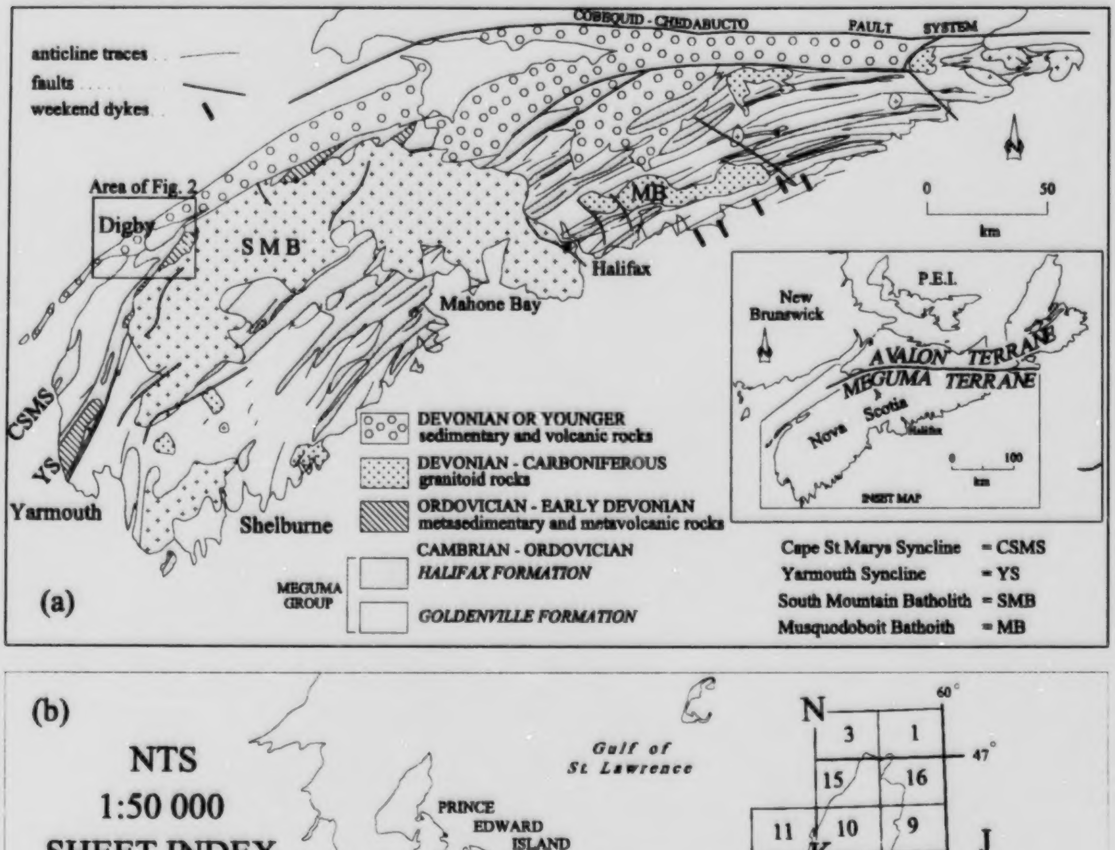

anticline traces
faults
weekend dykes
COBEQUID - CHEDABUCTO FAULT SYSTEM
Area of Fig. 2
Digby
SMB
MB
Halifax
Mahone Bay
CSMS
YS
Yarmouth
Shelburne
0 50 km
New Brunswick
P.E.I.
AVALON TERRANE
MEGUMA TERRANE
Nova Scotia
Halifax
0 100 km
INSET MAP
DEVONIAN OR YOUNGER sedimentary and volcanic rocks
DEVONIAN - CARBONIFEROUS granitoid rocks
ORDOVICIAN - EARLY DEVONIAN metasedimentary and metavolcanic rocks
CAMBRIAN - ORDOVICIAN
MEGUMA GROUP
HALIFAX FORMATION
GOLDENVILLE FORMATION
Cape St Marys Syncline = CSMS
Yarmouth Syncline = YS
South Mountain Batholith = SMB
Musquodoboit Bathoith = MB
(a)
(b)
NTS 1:50 000 SHEET INDEX of NOVA SCOTIA
Gulf of St Lawrence
PRINCE EDWARD ISLAND
Northumberland Strait
NEW BRUNSWICK
Bay of Fundy
Amherst
Springhill
New Glasgow
Truro
Windsor
Dartmouth
HALIFAX
Canso
Sydney
Liverpool
Yarmouth
Shelburne
ATLANTIC OCEAN
Sable Island
N
K
J
H
E
F
G
A
B
C
D
O
P
21
20
11
11C
11B
10N
10O
0 80 km
47°
46°
45°
44°
60°
62°
64°
66°

Figure 1. (a) Simplified geological map of the Meguma Terrane, Nova Scotia. Location of mapped area indicated as area of Figure 2. (b) National Topographic System (NTS) index map of Nova Scotia showing location of Figure 2.

assigned by Taylor (1969) and Smitheringale (1973) have been retained. In addition, the Halifax Formation has been divided into three new units which have been informally assigned member status. The metamorphic units are intruded by several suites of mafic sills (e.g. Doyle, 1979; Barr *et al.*, 1983). The Meguma Group, White Rock and Torbrook formations and mafic sills have been metamorphosed to chlorite grade as a result of regional greenschist facies metamorphism. Devonian granitoid rocks include part of the South Mountain Batholith and the Ellison Lake Pluton. Mesozoic units include the Triassic to Jurassic Wolfville, Blomidon and North Mountain formations.

Goldenville Formation

The Goldenville Formation occurs in the southwestern part of the mapped area (Fig. 2). It is poorly exposed, with outcrops limited to a few stream sections and logging roads. Distribution of this unit is more restricted than indicated previously (cf. Fig. 1a and Fig. 2), and the regional anticline and syncline shown by Taylor (1969) in the area of the Ellison Lake Pluton could not be confirmed. The Goldenville Formation consists of grey, massive to locally laminated or crosslaminated metasandstone and interbedded metasiltstone and slate. The metasandstone is typically fine grained, bedded on the metre scale, and has a poorly- to moderately-developed spaced cleavage. Carbonate and manganese concretions occur locally within metasandstone beds. Metasiltstone is typically green, massive to well laminated and well cleaved, and slate is dark grey and finely laminated. Stratigraphy (e.g. ratio of metasandstone to metasiltstone to slate) is highly variable, providing no obvious basis for stratigraphic subdivision of this unit within the mapped area. No fossils were observed, but a maximum age limit is provided by U-Pb 552 ± 5 Ma detrital titanite and 566 ± 8 Ma zircon (Krogh and Keppie, 1990). The contact between the Goldenville Formation and the overlying Halifax Formation is not exposed in the mapped area.

Halifax Formation

The Halifax Formation in the mapped area has been subdivided into three stratigraphic units, which are informally given member status here. From oldest to youngest, they are the Bloomfield, Acacia Brook and Bear River members.

Bloomfield Member

The lowermost part of Halifax Formation in the mapped area consists of a distinctive metasiltstone unit herein referred to as the Bloomfield member. This unit is exposed in a narrow, north-northeastward-trending belt at the contact between the Halifax and Goldenville formations in the southwestern part of the mapped area (Fig. 2). The distribution is well constrained for the northern three quarters of the unit (Fig. 2); however, projection of this unit to the southern map boundary is speculative, because no outcrop occurs in this area.

The Bloomfield member consists of distinctly banded maroon and green, very thinly bedded to medium bedded, locally crossbedded, metasiltstone to slate that locally displays a variegated texture (Fig. 3a). Metasandstone layers were not observed. Minor pink calcsilicate nodules occur locally. Contacts with adjacent units are not exposed, but the unit appears to be stratigraphically and structurally conformable with the underlying Goldenville Formation. A minimum stratigraphic thickness of 350 m is suggested from the exposed width.

Acacia Brook Member

The Acacia Brook member overlies the Bloomfield member and defines a north-northeastward-trending belt bounded by the Bloomfield member to the west and Acacia Brook to the east (Fig. 2). The northern part of this unit is well exposed; however, like the Bloomfield member, extension of the Acacia Brook member to the south is speculative, because exposure is limited in this area.

The Acacia Brook member consists mainly of light- to medium-grey, mainly planar laminated slate with minor, thin (<5 mm thick) laminations and lenses of well-cleaved, light grey metasiltstone. Crossbeds are commonly preserved. Metasandstone layers are rare. Locally the slate contains small (centimetre-scale), iron nodules (or weathered pyrite) and rust-brown (iron-rich?) laminations parallel to bedding horizons. No fossils were observed in this unit.

Contacts with the Bloomfield member are not exposed; however, based on regional-scale map patterns and structural similarities (see Structure and Metamorphism section), the contact is interpreted to be

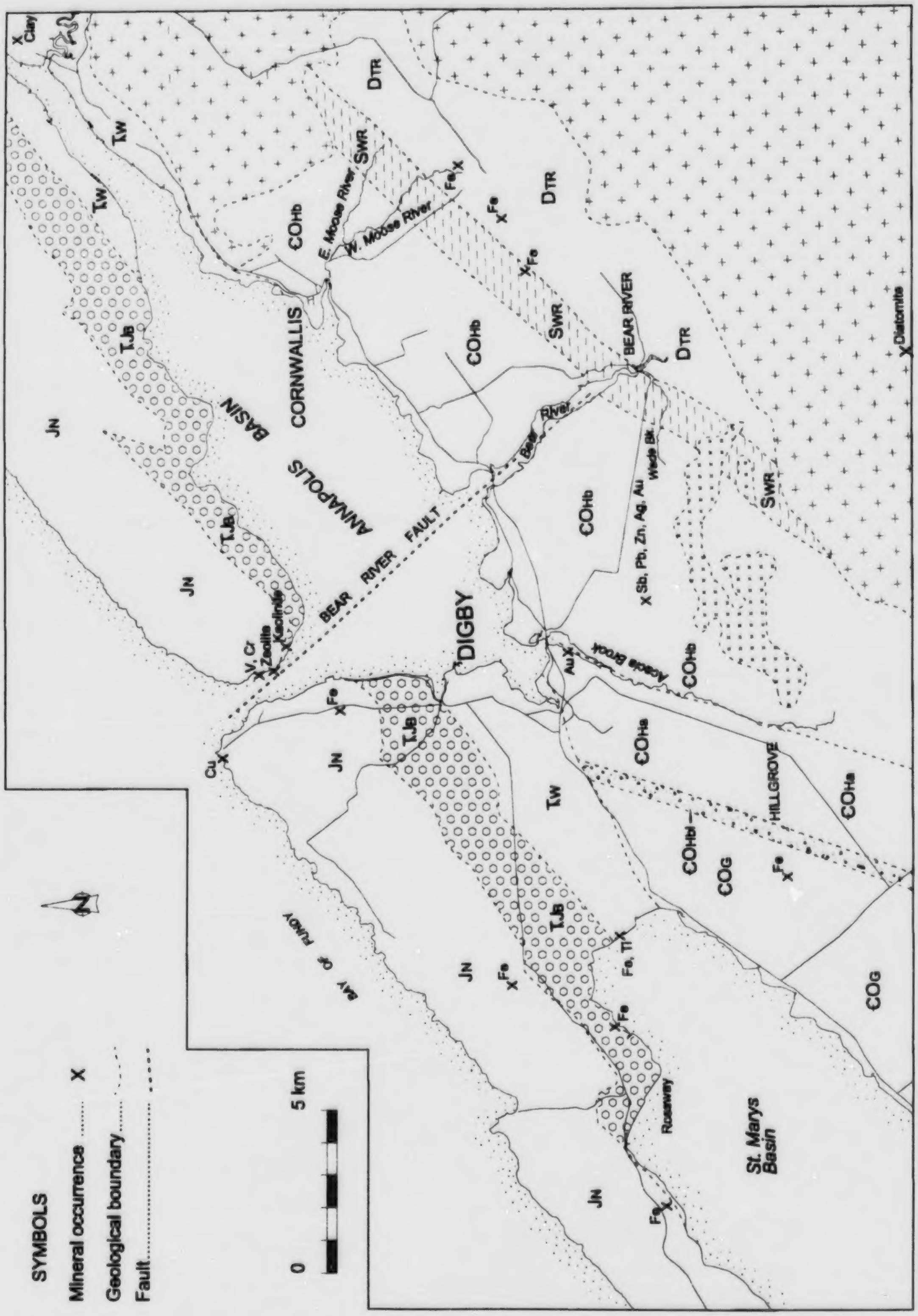

SYMBOLS
Mineral occurrence X
Geological boundary.......
Fault..........
0
5 km
BAY OF FUNDY
ANNAPOLIS BASIN
CORNWALLIS
BEAR RIVER FAULT
DIGBY
BEAR RIVER
Bear River
E. Moose River
W. Moose River
Wade Bk.
Acacia Brook
HILLGROVE
Rossway
St. Marys Basin
JN
TJB
Tw
ꞒOHb
ꞒOHa
ꞒOHbl
ꞒOG
DTR
SWR
Clay
Fe
Cu
V, Cr
Zeolite
Kaolinite
Au
Sb, Pb, Zn, Ag, Au
Fe, Ti
Diatomite

Figure 2. Preliminary geological map of the Digby area (21A/12).

LEGEND (Figure 2)

TRIASSIC TO JURASSIC

J_N	***NORTH MOUNTAIN FORMATION***: basalt and rare gabbroic dykes.
TJ_B	***BLOMIDON FORMATION***: red to red-brown siltstone, sandstone, shale and minor claystone.
T_W	***WOLFVILLE FORMATION***: red to red-brown sandstone, arkose and minor conglomerate.

LATE DEVONIAN

+ + +	***SOUTH MOUNTAIN BATHOLITH***: grey monzogranite to granodiorite.
× × ×	***ELLISON LAKE PLUTON***: grey granodiorite.

EARLY DEVONIAN

D_{TR}	***TORBROOK FORMATION***: dark grey to black shale, siltstone and quartzite; minor limestone and 'iron formation'; locally cleaved; minor mafic sills and dykes.

SILURIAN

S_{WR}	***WHITE ROCK FORMATION***: grey shale, siltstone and quartzite; minor calcsilicate lenses and rare limestone; locally well cleaved; minor mafic sills and dykes.

CAMBRIAN TO EARLY ORDOVICIAN

MEGUMA GROUP

HALIFAX FORMATION:

$ЄO_{Hb}$	Bear River member: grey silty slate and cleaved metasiltstone with thin quartz arenite laminations; rare metalimestone nodules; abundant mafic sills and dykes.
$ЄO_{Ha}$	Acacia Brook member: grey slate with minor iron-rich laminations and nodules.
$ЄO_{Hbl}$	Bloomfield member: maroon and green, variegated metasiltstone.
$ЄO_G$	***GOLDENVILLE FORMATION***: light grey metasandstone and minor siltstone and slate

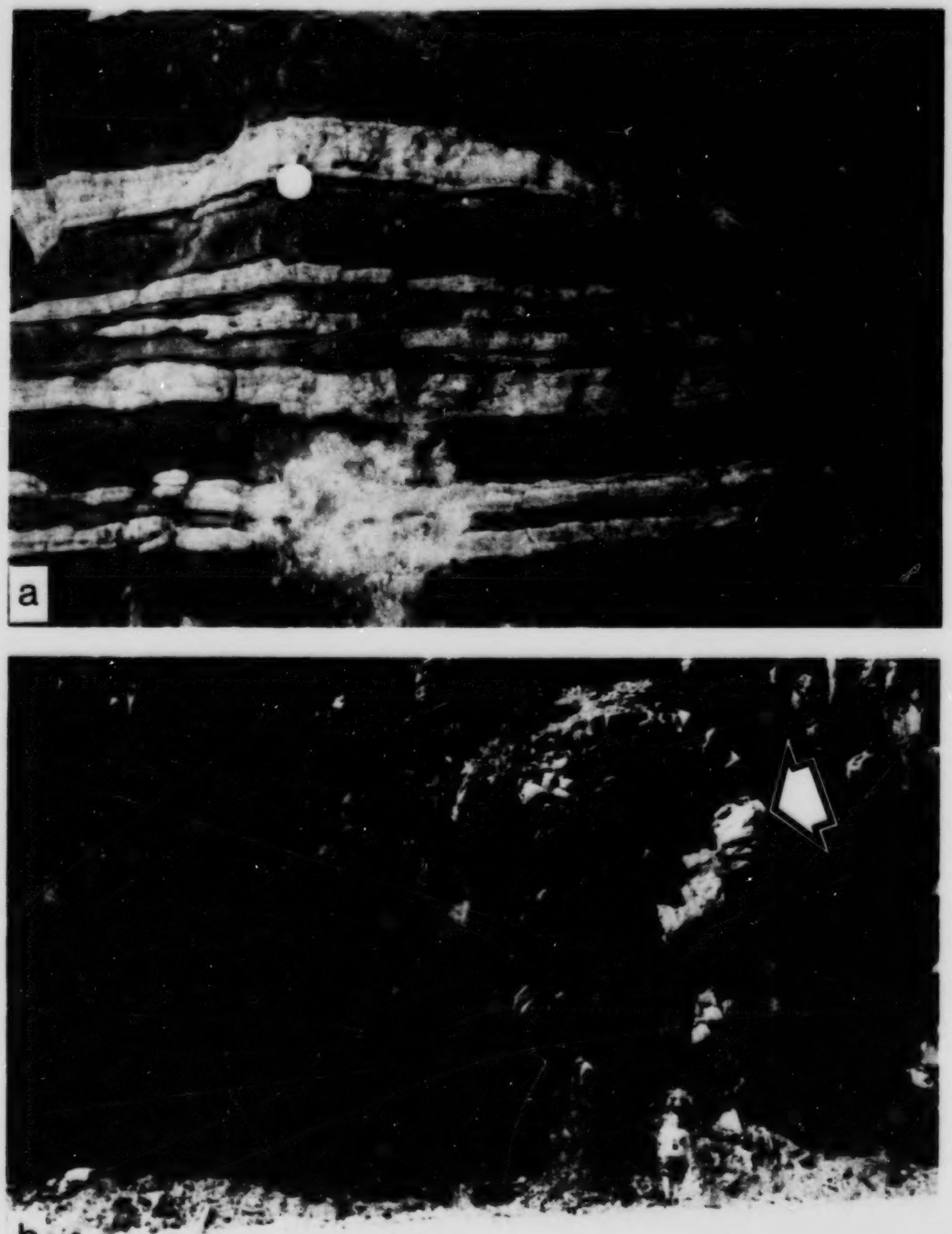


Figure 3. (a) Photograph of typical Bloomfield member, consisting of maroon (dark) and green (light), discontinuously banded (variegated) siltstone. Coin is 2.5 cm wide. (b) Photograph of typical Bear River member, consisting of silty slate, showing typical mesoscale fold found in this unit. Note folded Type I mafic sill, indicated by arrow. Person, in lower right of photograph, is 1.5 m tall, with hiking boots.

conformable with the Acacia Brook member. This interpretation is further supported by the general sedimentological similarity of these units; both consist mainly of planar laminated metasiltstone to slate. The contact with the overlying Bear River member was not observed and remains unclear. It coincides with Acacia Brook, which marks a prominent north-northeastward-trending linear feature. A faulted contact is suggested and supported by contrasts in structural style between the Bear River and Acacia Brook members (see Structure and Metamorphism section). A minimum stratigraphic thickness of 2200 m is suggested from the exposed width.

Bear River Member

The Bear River member is the uppermost and most extensive unit of the Halifax Formation in the area (Fig. 2). It is well exposed along brooks throughout much of the area; however, south of the Ellison Lake Pluton exposure is poor and distribution of this unit is speculative. The best continuous sections of this member are exposed along the lower part of Bear River.

The Bear River member consists of light- to dark-grey, banded to well laminated, cleaved silty slate, with minor, thin (<5 cm thick) metasiltstone and slate layers. A characteristic feature of this member is interlayered light grey, fine grained metasandstone that typically occurs as discontinuous, thin (<2 cm thick), lenticular crossbeds. Grey, massive, quartz-rich metasiltstone and metasandstone, forming layers up to 50 cm wide, are locally present. The metasiltstone typically contains abundant detrital muscovite. Rare, light grey metalimestone to silty metalimestone beds, lenses and nodules locally occur. Minor pyrite is common, occurring along laminae and fractures or as clusters of crystals. Pyrite beds up to 2 cm wide occur rarely.

Primary sedimentary structures are common and include cross- and graded-bedding, grooves, tool marks, ripple marks, small-scale slumping, and load casts. Fossil occurrences are generally sparse, although trace fossils and bioturbated layers are common. Early Tremadoc (earliest Ordovician) acritarch microfossils were reported by Doyle (1979) and specimens of the graptolite *Rhapdinopora flabelliforme* previously known as *Dictyonema flabelliforme* were observed within this unit (Smitheringale, 1973; this study) which are restricted to the Tremadoc (J. C. Russel, personal communication, 1999).

Contact with the overlying White Rock Formation is discussed below. Because of the numerous mesoscale folds in the Bear River member (Fig. 3b) (see Structure and Metamorphism section) a stratigraphic thickness could not be determined.

White Rock Formation

The White Rock Formation is well exposed in Bear River and Wade Brook (Fig. 2), where it has been studied in detail (e.g. Lane, 1975a, b, 1979; Doyle, 1979). It consists mainly of grey to dark grey slate and metasiltstone and minor light grey to white metasandstone. The slate is similar to the lithology in the underlying Bear River member and in isolated outcrops it is difficult to distinguish the two units. However, slates in the White Rock Formation are commonly darker, less laminated, and more silty than those in the Bear River member. The metasiltstone is laminated to massive, occurs in 5-20 cm thick beds, and cleavage is typically weakly to, locally, well developed. The metasandstone typically occurs as 1-10 cm thick, laminated to massive beds and discontinuous lenses. A characteristic feature of this formation is a thick (ca. 30 m), locally laminated and cross-stratified metasandstone layer. This layer is well exposed in Bear River, along a nearby road to the east and in Wade Brook, but appears to be discontinuous along strike. Rare, grey marble beds occur as thin (<15 cm thick) layers at the base of the formation, and thin (<3 cm thick) lenses of intraformational conglomerate, with a brown sandy matrix, locally occur near the top of the formation. Another feature of the White Rock Formation, not previously described in the area, is locally abundant pinkish-grey calcsilicate lenses.

Primary sedimentary structures are common and include crossbedding, grooves, tool marks, load casts and ripple marks. Fossil occurrences are sparse, although burrowing and grazing trace fossils and bioturbated layers are common. Ostracod fragments and calcareous oncolites have been recovered near the base of the formation, but no age was assigned to them (Lane, 1979). Upper Silurian vertebrate and crinoid remains have been collected near the top of the formation in addition to spore and chitinozoan microfossils (Blaise *et al.*, 1991; Bouyx *et al.*, 1997).

The contact between the White Rock Formation and the underlying Halifax Formation (Bear River member) is poorly defined. Smitheringale (1973) suggested that the base of the White Rock Formation should be placed at the bottom of the lowest 'quartzite' (cf. Doyle, 1979) or volcanic member (cf. Lane, 1979). In Wade Brook, the massive metasandstone sits with angular unconformity on slates of the Halifax Formation. In Bear River the base of the metasandstone is interlayered with black metasiltstone and a clear unconformity is not recognized. However, calcsilicate lenses typical of the White Rock Formation occur below the metasandstone along Bear River and continue down section to the limestone beds. We, in agreement with Lane (1979), place the contact between the White Rock and Halifax formations in this area at the base of the limestone. The presence of felsic tuff in the section could not be confirmed.

The upper contact between the White Rock and Torbrook formations is also problematic. Lane (1979) placed the upper contact just above the massive metasandstone based on the presence of Early Devonian fossils (Jensen, *in* Lane, 1979). However, fossils in this area have been reassigned to the Late Silurian by Blaise *et al.* (1991) and Bouyx *et al.* (1997). Our observations suggest the contact with the overlying Torbrook Formation is gradational and we place it above the intraformational conglomerate, where it occurs, and below the first occurrence of macroscopic Early Devonian fossils typical of the Torbrook Formation (see below). The exposed width of the White Rock Formation along Bear River suggests a stratigraphic thickness of approximately 1200 m.

Torbrook Formation

The Torbrook Formation occurs in a northeastward-trending belt between the White Rock Formation and the South Mountain Batholith. This unit is locally well exposed, particularly in the upper part of Bear River (Fig. 2). Outcrops of the Torbrook Formation were exposed temporarily during construction of a new penstock water pipeline in this area, which provided continuous sections through parts of the formation. These exposures, however, are now buried. The Torbrook Formation consists predominantly of metasiltstone and calcareous metasiltstone with minor slate, metasandstone, marble and rare ironstone. Most lithologies are poorly cleaved or lack cleavage. The metasiltstone is typically dark grey to black, but weathers pale grey. It is massive to well laminated, and commonly interlayered with thin (<2 cm thick), grey, laminated and crosslaminated metasandstone. In places the metasiltstone is pyrite-rich and weathers rusty-brown. Fossil-rich horizons are common within the metasiltstone. Dark grey slate is interlayered with the fossiliferous metasiltstone. White metasandstone beds become more abundant up section, range up to 2 m in thickness and are generally massive and locally crossbedded. Light grey, thin (<1 m) marble beds and nodules and thin (<10 cm) calcsilicate layers are interlayered with the metasiltstone. Ironstone, described as 'Iron Formation' by Woodman (1909) and Wright (1975), is exposed only in old mine trenches northeast of Bear River (Fig. 2). The ironstone consists of black, faintly laminated to massive, iron-rich sandstone. It was termed a chamositic sandstone by Doyle (1979).

Primary sedimentary structures are abundant and include crossbedding and ripple marks. The fossil assemblage includes brachiopods, corals, crinoids and pelecypods, and indicates an Early Devonian age (Smitheringale, 1973; Jensen, 1975a, b; Blaise *et al.*, 1991; Bouyx *et al.*, 1997).

The upper contact is not exposed due to intrusion of the South Mountain Batholith and therefore a reasonable estimate for the thickness of this unit is difficult to establish in the area.

Mafic Sills

Numerous mafic sills and rare dykes intruded the Halifax, White Rock and Torbrook formations (Smitheringale, 1973) and have generally been divided into two suites referred to as Type I and Type II (Doyle, 1979; Barr *et al.*, 1983; this study). Type I sills are restricted to the Halifax Formation. They are typically light grey, fine grained, thin (<2 m thick), vesicular, have narrow chilled margins, and are highly altered, with only relict igneous textures preserved and no igneous minerals. Phenocrysts displaying olivine morphologies are completely pseudomorphed by carbonate minerals, chlorite, and other secondary minerals. Type I sills are folded by F_1 folding (Fig. 3b) (see Structure and Metamorphism section) and soft-sediment deformational features are preserved along some of the sill contacts. These features suggest intrusion of the sills prior to deposition of the White Rock and Torbrook formations, as suggested by Doyle (1979) and Barr *et al.* (1983).

In comparison, Type II sills are dark grey to black, coarse grained, and generally wider and less abundant than Type I sills. Type II sills occur in the Halifax, White Rock and Torbrook formations and have not been observed in the South Mountain Batholith or Ellison Lake Pluton. Folded Type II sills were not observed; however, many of these sills are deformed and cleaved and no discordant examples have been observed, suggesting that these sills, like Type I sills, are folded by regional F_1

folding. Type II sills near the South Mountain Batholith are contact metamorphosed by the intrusion. Alteration is not as strong as it is in the Type I sills. Igneous textures and minerals are generally well preserved, with pyroxene only partially pseudomorphed by secondary minerals. Olivine, or evidence for former presence of olivine, was not observed.

A third set of mafic sills was recognized during this study. They are black, medium- to coarse-grained, uncleaved, unaltered and contain augite and pigeonite. These sills are texturally and mineralogically similar to basalts of the North Mountain Formation and are interpreted to be related to that formation. However, these sills are rare and were observed only in the Halifax Formation.

Devonian Plutonic Units

Plutonic units in the mapped area consist of the Ellison Lake Pluton and parts of the South Mountain Batholith (Fig. 2). A study of these units was not a priority of this project, because these units have been part of other detailed studies (Allen and Barr, 1983; MacDonald *et al.*, 1992; MacDonald, 1994; Ham, 1994).

The Ellison Lake Pluton is poorly exposed, therefore its distribution is based on limited outcrop, diamond-drill holes, trenching, boulder mapping and airborne radiometric data (Allen, 1982; Allen and Barr, 1983; Doyle, 1979). The South Mountain Batholith is better exposed, but outcrops are generally confined to streams and rivers (Ham, 1994). Both units consist of medium- to coarse-grained monzogranite and granodiorite with locally well-developed megacrysts of K-feldspar. The South Mountain Batholith has yielded U-Pb ages of ca. 370 Ma (monazite) (Clarke *et al.*, 1993; Harper, 1988). The Ellison Lake Pluton is generally similar in texture and mineralogy to the South Mountain Batholith and is interpreted to be of similar age (e.g. Allen and Barr, 1983; Ham, 1994).

Wolfville Formation

The Wolfville Formation is not well exposed in the mapped area, but its presence is confirmed from water wells along the shoreline of the Annapolis Basin (Trescott and Lin, *in* Doyle, 1979). Where exposed, this formation consists mainly of pink to red, coarse grained sandstone and conglomerate with minor interbeds of red to red-brown siltstone and shale.

The Wolfville Formation is interpreted to unconformably overlie the Meguma Group and the South Mountain Batholith (Fig. 2). Vertebrate faunal remains in exposures along the southern side of the Minas Basin (northeast of the mapped area) indicate a Middle to Late Triassic age for this unit (e.g. Olsen *et al.*, 1989). An estimate of the minimum thickness of the Wolfville Formation, based on exposed width, is approximately 450 m.

Blomidon Formation

The Blomidon Formation is better exposed than the Wolfville Formation and at Rossway, on Digby Neck, approximately 400 m of stratigraphy is exposed. This section represents the majority of the estimated 550 m stratigraphic thickness inferred from the exposed width of the unit. The Blomidon Formation consists mainly of red-brown to locally grey-green siltstone and minor sandstone and shale. Caliche nodules are locally common and evaporite beds have been reported at Rossway (Wade *et al.*, 1996).

Although the contact is not exposed in the mapped area, the Blomidon Formation is interpreted to conformably overly the Wolfville Formation based on borehole data (Jong, 1985; Wade *et al.*, 1996). Palynomorph assemblages within the Blomidon Formation indicate a mainly Late Triassic age, with the very top of the formation extending into the Jurassic (Wade *et al.*, 1996).

North Mountain Formation

The North Mountain Formation is well exposed along the coast of the Bay of Fundy, and consists of a succession of subaerial basaltic flows. In the Digby Neck area (Fig. 2), thick, coarse grained lower and upper flows are separated by seven or more thin amygdaloidal flows with abundant zeolites (e.g. Papezik *et al.*, 1988). The composite thickness is about 400 m (Wade *et al.*, 1996; this study). Coarse grained to pegmatitic gabbroic dykes, ranging in thickness from a few centimetres to approximately 5 m, are associated with the basalt. These dykes have been observed throughout the formation and are not restricted to any one flow.

A U-Pb (zircon) age of 202 ± 1 Ma (Early Jurassic) has been established for the pegmatitic gabbroic dykes (Hodych and Dunning, 1992) and provides a minimum age for the North Mountain Formation. The contact with the underlying Blomidon Formation is not exposed; however, siltstone close to the basalt appears to be metamorphosed and hydrothermally altered, consistent with a depositional contact.

Structure and Metamorphism of Cambrian to Early Devonian Rocks

Introduction

The Cambrian-Early Devonian stratified rocks (i.e. Meguma Group and White Rock and Torbrook formations) and Types I and II mafic sills were deformed during the Acadian Orogeny. This deformation resulted in regional-scale northeastward-trending folds with an axial planar cleavage and regional greenschist facies metamorphism (Taylor 1969; Smithingale, 1973). An apparent disconformity to local angular unconformity occurs between the Halifax and White Rock formations in the study area and similar observations have been documented in the Yarmouth area (e.g. Schenk, 1997). This pre-White Rock Formation deformation is interpreted to be minor and local in extent because contacts between these units are regionally conformable and folding of both units defines the first episode of regional deformation.

Folds

Previously published maps of the area showed that the dominant structures in the Cambrian-Early Devonian metamorphic rocks are regional-scale synclines in the Bear River and Hillgrove areas, separated by an anticline (Taylor, 1969; Smitheringale, 1973). Our observations do not support this earlier interpretation. Although stratigraphy is locally repeated within mapped units by mesoscale folds, regionally the mapped units systematically young from west to east with no apparent repetition (Fig. 2).

The character of regional folding varies throughout the mapped area and based on fold styles can be subdivided into three distinct structural domains. Domain I occupies most of the eastern part of the mapped area adjacent to the South Mountain Batholith and includes the White Rock and Torbrook formations. Domain II occupies the central part of the mapped area and includes the Bear River Member. Domain III comprises the western part of the area and includes the Acacia Brook and Bloomfield members of the Halifax Formation and the Goldenville Formation.

Domain I

A regional syncline was indicated in the Bear River area by Taylor (1969) and Smitheringale (1973), with the fold structure defined by repetition of the White Rock Formation in the area adjacent to the South Mountain Batholith. However, the southeastern limb of this fold was defined only on the basis of aeromagnetic contour patterns (Smitheringale, 1973, p. 41) and comparison with other synclines involving the White Rock and Torbrook formations to the northeast of the mapped area (e.g. Crosby, 1962; Smitheringale, 1973). In areas of fairly continuous outcrop (along Bear River and the exposed penstock trench) bedding on the northwestern limb of the 'syncline' steepens progressively toward the southeast, eventually becoming overturned and dipping to the northwest. Sedimentary 'way-up' structures in the contact aureole of the South Mountain Batholith are generally obliterated; however, lithologies appear to be more similar to those of the Torbrook Formation than the White Rock Formation. Hence, the existence of the 'Bear River Syncline' defined by Taylor (1969) and Smitheringale (1973) could not be confirmed in this study.

The structural data for this domain are consistent with a southeastward-dipping to overturned fold limb, with overturned poles to bedding plotting in the southeast quadrant of stereoplots (Fig. 4a). Cleavage is steep and strikes northeast, parallel to bedding (Fig. 4a). Intersection lineations are poorly developed, but plunge shallowly to the southwest (Fig. 4a). Only one mesoscopic fold was observed in the White Rock Formation.

Domain II

Folding within the Bear River member of the Halifax Formation is characterized by numerous mesoscale (metres to hundreds of metres in wavelength) folds which can be observed in roadcuts (Fig. 3b) and along stream sections. Similar folding was documented in this unit by Smitheringale (1973). Although local variation occurs in fold geometry, collectively, structural data for this area are systematic and indicate that folding is characterized by upright, horizontal folds trending northeast-southwest; stereoplots of poles to bedding (Fig. 4b) define a subvertical π girdle, indicating a subvertical fold profile plane; poles to cleavage (Fig. 4b) are steep, indicating that cleavage strikes roughly parallel to bedding and has a uniform trend throughout the area; bedding-cleavage intersection data (Fig. 4b) indicate that fold hinges plunge

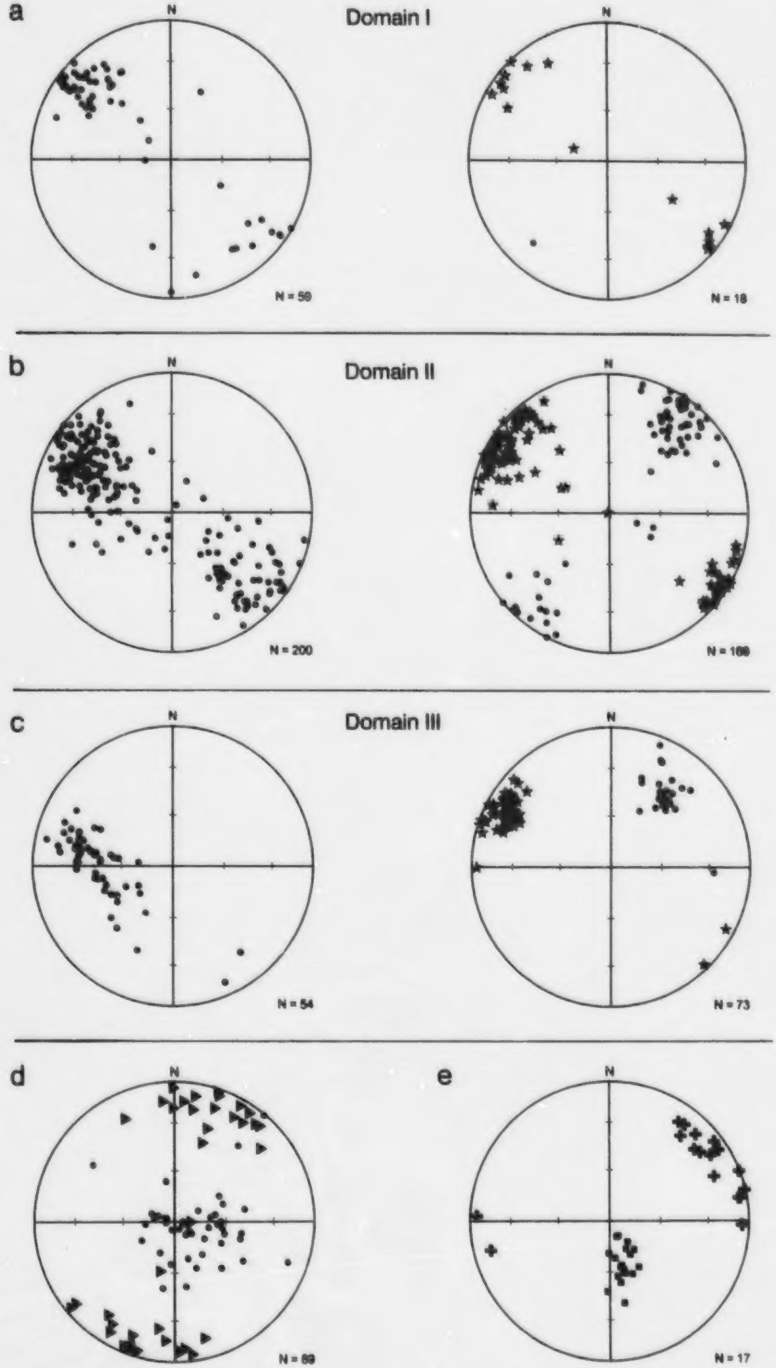


Figure 4. Equal area stereoplots of structural data for the Digby area. (a-c) Represent data for three structural domains defined within the area (see text); left streoplots represent poles to bedding, right stereoplots represent poles to cleavage (stars) and bedding-cleavage intersection lineations (filled circles). (d) Stereoplot of kink folds in the Digby area; filled triangles represent poles to axial planes and filled circles are fold hinges. (e) Stereoplot of crenulation cleavage data; crosses represent poles to crenulation cleavage (S_2) and filled squares represent crenulation lineation (L_2).

shallowly to the northeast and southwest. Structural data for the Type I sills parallel those for bedding and associated cleavage in the Bear River member.

The abundance of small-scale folds, general poor exposure, a lack of obvious vergence in mesoscale folds and the lack of stratigraphic marker horizons in the Bear River member inhibit construction of a cross-section through this unit. It is possible, and maybe probable, that the enveloping surface of mesoscale folds is shallow and that exposure of the Bear River member within the area represents only a thin stratigraphic interval. This interpretation is consistent with the uniform character of this unit over such a large area.

Domain III

Previous mapping in the Hillgrove area defined map patterns which implied a syncline in the Halifax Formation in the area, with the Goldenville Formation enclosing the southern part of the Ellison Lake Pluton and occurring along the southern part of the mapped area (Taylor, 1969). This interpretation is not, however, supported by our observations for several reasons. (1) Limited exposure around the Ellison Lake Pluton consists of spotted hornfels, interpreted here to represent contact metamorphosed Halifax Formation. (2) Bedding dips consistently to the east across the area, including the area underlain by the Goldenville Formation and the Bloomfield and Acacia Brook members (Fig. 4c). Bedding-cleavage relations and sedimentary structures indicate consistent, southeastward vergence (younging) across this section (Fig. 4c). (3) No repetition of stratigraphy was observed to support a regional fold.

Based on these observations, the Goldenville Formation and the Bloomfield and Acacia Brook members of the Halifax Formation in the mapped area form the southeastern limb of a regional scale anticline. Bedding-cleavage intersection lineation data indicate that the fold plunges moderately (~35°) to the northeast (Fig. 4c).

Kink Folds

Mesoscale kink folds are common in slaty units throughout the mapped area, especially in the Bear River member. These kink folds deformed both bedding and cleavage, with axial planes (S_2) typically west-northwestward-trending with steep fold hinges (Fig. 4d). Subhorizontal kink folds with shallow northeastward- and southwestward-plunging fold hinges (Fig. 4d) are also common, but these were not as often recorded in the field because of generally subhorizontal exposures.

Crenulation Cleavage

A crenulation cleavage (S_2) deforms axial planar cleavage related to regional folds (S_1) in the western part of the mapped area and is particularly well developed in the Bloomfield and Acacia Brook members, where this fabric is locally the dominant cleavage. A crenulation cleavage also occurs locally in the western part of the Bear River member and in slate intervals in the Goldenville Formation.

S_2 defines a systematic fabric which strikes south-southeast to north-northwest and dips steeply to the southwest (Fig. 4e). The crenulation lineation (L_2), defined by the intersection of S_1 and S_2, plunges steeply south-southeast (Fig. 4e).

Faults

Minor brittle faults are present throughout the mapped area. Most are not regionally significant, with small displacements of a few metres. Doyle (1979) documented both north-northeastward- and northwestward-trending, low-angle reverse and high-angle normal faults with vertical to steeply plunging slickensides. Horizontal slickensides are not common. Many of these faults were interpreted to be related to folding (Doyle, 1979); however, faults with similar orientations are present in the Mesozoic units and suggest that some of the faulting is post-Triassic (e.g. the Bear River Fault, Fig. 2).

Metamorphism

Regional metamorphism associated with the Acadian Orogeny was at greenschist facies conditions, with a peak metamorphic mineral assemblage of muscovite + chlorite + albite in the pelitic rocks and chlorite + albite + quartz ± epidote ± biotite, typically with abundant calcite, in the associated mafic sills. Fine grained biotite occurs in some pelitic samples, but is not common.

The intrusion of the South Mountain Batholith and Ellison Lake Pluton produced well-developed contact metamorphic aureoles that are superimposed on regional greenschist-facies mineral assemblages and textures. The first evidence of contact metamorphism in the pelitic rocks is the development of small, randomly oriented decussate biotite and muscovite grains in spotted slates. Original sedimentary structures are still well preserved. The mineral assemblage in these rocks are characteristic of the albite-epidote hornfels facies (e.g. Yardley, 1989). Closer to the intrusions, within a zone approximately 1000 m from the exposed contacts, cordierite and locally andalusite are developed and the rock displays a hornfelsic texture (Mahoney, 1996). Immediately adjacent to the intrusions andalusite is more abundant than cordierite and the rocks locally display a gneissic texture. The mineral assemblage in this part of the contact aureole is characteristic of the hornblende-hornfels facies (e.g. Yardley, 1989). This facies forms the greater part of the outcrop width of the aureole and continues up to the intrusive contacts. Better defining the contact metamorphism in the Bear River area is currently the subject of a B.Sc. honours thesis at Acadia University, Wolfville by Brian Campbell.

Economic Geology

Minor metallic mineral showings occur throughout the mapped area (Fig. 2). Pyrite and, locally, arsenopyrite commonly occur along bedding, fractures, and veins in many of the sedimentary rocks and sills in the Halifax, White Rock and Torbrook formations. Some veins contain arsenopyrite, chalcopyrite and pyrite with rare jamesonite, pyrrhotite, sphalerite and stibnite. These veins also have anomalous gold values (Nova Scotia Mineral Occurrence Database). Iron ore was mined (Wright, 1975) from hematite and magnetite rich layers in the Torbrook Formation. Minor chalcopyrite, chalcocite and malachite occur as stringers in the North Mountain Formation. Magnetite locally occurs finely disseminated in the basalt or concentrated in lenses, veins and along fractures. Zeolite minerals are common in vesicles and veins in the basalt. Kaolinite has been noted in sandstones along the contact between the basalt and the underlying Blomidon Formation (Nova Scotia Mineral Occurrence Database). A reported vanadium and chromium occurrence in the basalt was not verified (Nova Scotia Mineral Occurrence Database). Minor showings of clay, bog iron, and placer ilmenite and magnetite occur throughout the area.

In many localities in the Halifax Formation and a few in the North Mountain Formation the rocks are quarried for crushed stone and a few of the many sand and gravel deposits are presently being exploited. Many of the larger gabbroic Type II sills have potential as building stone.

Discussion and Preliminary Conclusions

The overall stratigraphy in the mapped area is broadly comparable to that documented elsewhere in the Meguma Zone (e.g. Crosby, 1962; Smitheringale ,1973). A significant contribution provided by this project to the understanding of the Meguma Group in the area is the subdivision of the Halifax Formation into three lithologically discrete members. The Bloomfield member represents the lowest unit and together with the overlying Acacia Brook member marks the transition from the Goldenville Formation to the Halifax Formation. The Bear River member represents the uppermost unit in the Halifax Formation and is characterized by abundant metasiltstone and metasandstone layers. The Bear River member contains earliest Tremodoc (Lower Ordovician) fossils, which suggests that the Acacia Brook and Bloomfield members, together with the Goldenville Formation may be Cambrian in age.

The Bloomfield and Acacia Brook members display lithologic similarities to the Moshers Island Member (Waldron, 1992; Schenk, 1995a, 1997) in the Mahone Bay area (Fig. 1). In the Mahone Bay area the Moshers Island Member is conformably overlain by sulphide-rich black slate of the Cunard Member (Waldron, 1992; Schenk, 1995a, 1997). Such sulphide-rich black slate is not present in the Bear River map area. The Bear River member may be a facies-equivalent unit to the Cunard Member, but the presence of the graptolite *Rhapdinopora flabelliforme* suggests that it is more similar to the younger Feltzen Formation of the Meguma Group (Schenk, 1997). The apparent lack of the Cunard Member, which is regionally extensive elsewhere in the Meguma Group (Waldron, 1992; Schenk, 1995a, 1997; Horne *et al.*, 1997), could reflect lateral facies variations or tectonic removal along a possible fault coincident with Acacia Brook.

Fossils in the upper part of the White Rock Formation indicate a Silurian age for most, if not all, of the formation. This age suggests a considerable time gap between the top of the Halifax Formation (Lower Ordovician) and deposition of the White Rock Formation, supporting the presence of an unconformity between the Halifax and White Rock formations in the area. The Torbrook Formation contains Early Devonian fossils and is in gradational contact with the underlying White Rock Formation.

Two prominent sets of mafic sills are present. Type I sills are restricted to the Meguma Group and are inferred to be penecontemporaneous with their host rocks and therefore Cambrian to Early Ordovician in age. Type II sills intruded the Meguma Group, White Rock and Torbrook formations, but predated the South Mountain Batholith, therefore they are Early to Middle Devonian in age. Based on limited data, both sets were interpreted to be tholeiitic transitional to alkalic, with the older sills more alkalic in character, and speculated to have been emplaced in a continental within-plate environment (Barr *et al.*, 1983). However, additional geochemical studies are required to verify these earlier results.

In contrast to Taylor (1969) and Smitheringale (1973), our mapping suggests that there is no repetition of stratigraphic units across the mapped area. Regional scale folding is characterized by a moderate to steep, eastward-dipping limb in the west (Domain III), a complexly folded middle zone representing a shallow, buckled limb (Domain II) and a moderately to steeply (locally overturned), southeastward-dipping limb in the east (Domain I). The observed folding and distribution of map units may represent a regional monocline or the eastern limb of a regionally significant anticline. An added complexity in this model is the possible presence of a fault between the Acacia Brook and Bear River members of the Halifax Formation. A pronounced topographic linear feature marks this boundary, together with well-developed crenulation fabrics and a modest change in fold geometry (compare Figs. 4b and 4c) across this feature.

Kink folds and crenulation fabrics clearly define post-Acadian deformation, overprinting axial planar cleavage related to regional folds, and may be related to Middle Carboniferous deformation documented along the coastal section between Yarmouth and Meteghan (Culshaw and Liesa, 1997; Fig. 1). Culshaw and Liesa (1997) were able to define distinct shear zones along the coast, where exposure is excellent. Within the mapped area, definition of distinct shear zones is inhibited by poor exposure. However, the most intense crenulation development is confined to the Acacia Brook and Bloomfield members (Fig. 2), and, as noted above, may be related to a fault between the Acacia Brook and Bear River members. A shear zone in this area could represent along-strike extension of the shear zones in the Yarmouth Syncline (Fig. 1) defined by Culshaw and Liesa (1997) and Keppie and Dallmeyer (1995). Recognition of post-Acadian deformation in the mapped area supports the prediction of Culshaw and Liesa (1997) of inland extension of the deformation that they defined along the coast.

Mesozoic units unconformably overlie the Cambrian-Early Devonian metamorphic units and are tilted to the northwest.

Acknowledgments

Sandra Barr and Bob Raeside are thanked for numerous discussions regarding the geology of southwestern Nova Scotia, and for the use of samples and unpublished information. Eibhlin Doyle is thanked for providing unpublished field notes. We also thank John Waldron and Nick Culshaw for discussions on sedimentological and structural aspects of the study area. Comments on the manuscript by Sandra Barr were very helpful. Editorial comments by Kathy Mills improved the style of the manuscript.

References

Allen, P. L. 1982: Petrology and geochemistry of Ellison Lake Pluton, Digby County, Nova Scotia; B.Sc. honours thesis, Acadia University, Wolfville, Nova Scotia.

Allen, P. L. and Barr, S. M. 1983: The Ellison Lake Pluton: a cordierite-bearing monzogranitic intrusive body in southwestern Nova Scotia; Canadian Mineralogist, v. 21, p. 583-590.

Barr, S. M., Doyle, E. M. and Trapasso, L. S. 1983: Geochemistry and tectonic implications of mafic sills in Lower Paleozoic formations of southwestern Nova Scotia; Maritime Sediments and Atlantic Geology, v. 19, p. 73-87.

Benn, K., Horne, R. J., Kontak, D. J., Pignotta, G. S. and Evans, N. G. 1997: Syn-Acadian emplacement model for the South Mountain Batholith, Meguma Terrane, Nova Scotia: Magnetic fabric and structural analysis; Geological Society of America Bulletin, v. 109, p. 1279-1293.

Blaise, J., Bouyx, E., Goujet, D., LeMenn, J. and Paris, F. 1991: Le Silurian superieur de Bear River (Zone de Meguma, Nouvelle-Ecosse): faune, biostratigraphie et implications paleogeographiques; Geobios (Lyon), v. 24, p. 167-182.

Bouyx, E., Blaise, J., Brice, D., Degardin, J. M., Goujet, D., Gourvennec, R., LeMenn, J., Lardeux, H., Morzadec, P. and Paris, F. 1997: Biostratigraphie et paleobiogeographie du Siluro-Devonien de la zone de Meguma (Nouvelle-Ecosse, Canada); Canadian Journal of Earth Sciences, v. 34, p. 1295-1309.

Clarke, D. B., MacDonald, M. A., Reynolds, P. H. and Longstaffe, F. J. 1993: Leucogranites from the east part of the South Mountain Batholith, Nova Scotia; Journal of Petrology, v. 34, p. 653-679.

Crosby, D. G. 1962: Wolfville map-area, Nova Scotia; Geological Survey of Canada, Memoir 325.

Culshaw, N. and Liesa, M. 1997: Alleghanian reactivation of the Acadian fold belt, Meguma Zone, southwest Nova Scotia; Canadian Journal of Earth Sciences, v. 34, p. 833-847.

Doyle, E. M. 1979: Geology of the Bear River area, Digby and Annapolis counties, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Ham, L .J. 1994: Geological map of Digby, Nova Scotia (NTS Sheet 21A/12), South Mountain Batholith Project; Nova Scotia Department of Natural Resources, Mines and Energy Branches, Map 94-07, scale 1:50 000.

Harper, C. L. 1988: On the nature of time in the cosmological perspective; Ph.D. thesis, Oxford University, Oxford.

Hicks, R., Jamieson, R. A. and Reynolds, P. H. in press: Detrital and metamorphic $^{40}Ar/^{39}Ar$ ages from muscovite and whole-rock samples, Meguma Supergroup, southern Nova Scotia; Canadian Journal of Earth Sciences.

Hodych, J. P. and Dunning, G. R. 1992: Did the Manicouagan impact trigger end-of-Triassic mass extinction?; Geology, v. 20, p. 51-54.

Horne, R. J., Baker, D., Feetham, M. and MacDonald, L. 1997: Preliminary geology of the Waverley-Halifax Airport area, central Nova Scotia: Some insights on the timing of deformation and vein formation in the Meguma Group; *in* Minerals and Energy Branch, Report of Activities 1996, eds. D. R. MacDonald and K. A. Mills; Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Report 97-1, p. 57-72.

Jensen, L. R. 1975a: The Torbrook Formation; Maritime Sediments, v. 11, p. 107-118.

Jensen, L. R. 1975b: The Torbrook Formation; *in* Ancient Sediments of Nova Scotia, ed. I. M. Harris; Society of Economic Paleontologists and Mineralogists, Eastern Section Field Trip, p. 64-73.

Jong, W. 1985: The subsurface lithostratigraphy of the Triassic Blomidon and Upper Wolfville formations (Fundy Basin) of the central Annapolis Valley, Nova Scotia; B.Sc. honours thesis, Acadia University, Wolfville, Nova Scotia.

Keppie, J. D. 1993: Synthesis of Palaeozoic deformational events and terrane accretion in the Canadian Appalachians; Geol Rundsch, v. 82, p. 381-431.

Keppie, J. D. and Dallmeyer, R. D. 1995: Late Paleozoic collision, delamination, short-lived magmatism, and rapid denudation of the Meguma Terrane (Nova Scotia, Canada): constraints from $^{40}Ar/^{39}Ar$ isotopic data; Canadian Journal of Earth Sciences, v. 32, p. 644-659.

Krogh, T. E. and Keppie, J. D. 1990: Age of detrital zircon and titanite in the Meguma Group, southern Nova Scotia, Canada: clues to the origin of the Meguma Terrane; Tectonophysics, v. 177, p. 307-323.

Lane, T. E. 1975a: Stratigraphy of the White Rock Formation; Maritime Sediments, v. 11, p. 87-106.

Lane, T. E. 1975b: Stratigraphy of the White Rock Formation; *in* Ancient Sediments of Nova Scotia, ed. I. M. Harris; Society of Economic Paleontologist and Mineralogists, Eastern Section Field Trip, p. 43-62.

Lane, T. E. 1979: The stratigraphy and sedimentology of the White Rock Formation (Silurian), Nova Scotia, Canada; M.Sc. thesis, Dalhousie University, Halifax, Nova Scotia.

MacDonald, M. A. 1994: Geological map of the South Mountain Batholith, western Nova Scotia; Nova Scotia Department of Natural Resources, Mines and Energy Branches, Map 94-01, scale 1:250 000.

MacDonald, M. A., Horne, R. J., Corey, M. C. and Ham, L. J. 1992: An overview of recent bedrock mapping and follow-up petrological studies of the South Mountain Batholith, southwestern Nova Scotia, Canada; Atlantic Geology, v. 28, p. 7-28.

Mahoney, K. L. 1996: The contact metamorphic aureole of the South Mountain Batholith, Nova Scotia; M.Sc. thesis, Acadia University, Wolfville, Nova Scotia.

Muecke, G. K, Elias, P. and Reynolds, P. H. 1988: Hercynian/Alleghanian overprinting of an Acadian

Terrane: ^{40}Ar/^{39}Ar studies in the Meguma Zone, Nova Scotia; Chemical Geology, v. 73, p. 153-167.

Olsen, P .E., Schlische, R. W. and Gore, P. J. W. 1989: Tectonic, depositional and paleoecological history of the early Mesozoic rift basins, Eastern North America; American Geophysical Union, Washington, Field Trip Guidebook T-351.

Papezik, V. S., Greenough, J. D., Colwell, J. A. and Mallinson, T. J. 1988: North Mountain Basalt from Digby, Nova Scotia: models for a fissure eruption from stratigraphy and petrochemistry; Canadian Journal of Earth Sciences, v. 25, p. 74-83.

Rogers, H. D. 1986: Igneous and metamorphic geology of Shelburne and eastern Yarmouth counties, Nova Scotia; Geological Survey of Canada, Open File 1374.

Schenk, P. E. 1995a: Meguma Zone; *in* Chapter 3 of the Appalachian-Caledonian Orogen in Canada and Greenland, ed. H. Williams; Geological Survey of Canada, Geology of Canada, v. 6, p. 261-277.

Schenk, P. E. 1995b: Annapolis Belt; *in* Chapter 4 of the Appalachian-Caledonian Orogen in Canada and Greenland, ed. H. Williams; Geological Survey of Canada, Geology of Canada, v. 6, p. 367-383.

Schenk, P. E. 1997: Sequence stratigraphy and provenance on Gondwana's margin: The Meguma Zone (Cambrian to Devonian) of Nova Scotia, Canada; Geological Society of America Bulletin, v. 109, p. 395-409.

Smitheringale, W. G. 1973: Geology of parts of Digby, Bridgetown, and Gaspereau Lake map areas, Nova Scotia; Geological Survey of Canada, Memoir 375.

Taylor, F. C. 1965: Silurian stratigraphy and Ordovician-Silurian relationships in southwestern Nova Scotia; Geological Survey of Canada, Paper 64-13.

Taylor, F. C. 1967: Reconnaissance geology of Shelburne map-area, Queens, Shelburne, and Yarmouth counties, Nova Scotia; Geological Survey of Canada, Memoir 349.

Taylor, F. C. 1969: Geology of the Annapolis-St. Marys Bay map-area, Nova Scotia (21A, 21B East Half); Geological Survey of Canada, Memoir 358.

Wade, J. A., Brown, D. E., Traverse, A. and Fensome, R. A. 1996: The Triassic-Jurassic Fundy Basin, Eastern Canada: regional setting, stratigraphy and hydrocarbon potential; Atlantic Geology, v. 32, p. 189-231.

Waldron, J. W. F. 1992: The Goldenville-Halifax transition, Mahone Bay, Nova Scotia: relative sea-level rise in the Meguma source terrane; Canadian Journal of Earth Sciences, v. 29, p. 1091-1105.

Williams, H. 1979: Appalachian Orogen of Canada; Canadian Journal of Earth Sciences, v. 16, p. 792-807.

Williams, H. and Hatcher, R. D. Jr. 1983: Appalachian suspect terranes; *in* Contributions to the Tectonics and Geophysics of Mountain Chains, eds. R. D. Hatcher Jr., H. Williams and I. Zietz; Geological Society of America, Memoir 158, p. 33-53.

Woodman, J. E. 1909: Report on the iron ore deposits of Nova Scotia (part 1); Canadian Department of Mines, v. 20, p. 13-15.

Wright, J. D. 1975: Iron deposits of Nova Scotia; Nova Scotia Department of Mines, Economic Geology Series 75-1, p. 75-76.

Yardley, B. W. D. 1989: An Introduction to Metamorphic Petrology; Longman Earth Science Series.

Fluid composition and thermal regime during Zn-Pb mineralization in the Lower Windsor Group, Nova Scotia, Canada[1]

G. Chi[2], D. J. Kontak and A. E. Williams-Jones[3]

The Zn-Pb-Ba-Cu-Ag-F deposits hosted by Lower Windsor Group (early Carboniferous) carbonates in Nova Scotia are located along the southern magin of the Maritimes basin. Various geochemical studies indicate that the deposits were formed by fluids expelled from the basin, but it remains unclear whether the ore-forming fluids for different deposits were derived from a common source region in the central part of the basin, as proposed previously, or from separate source regions. It is also unknown how the ore fluids were conveyed from the source regions to the sites of mineralization and whether or not the mineralizing systems of different deposits were hydrologically related. This paper addresses these problems through a compilation of regional fluid composition and temperature data and thermal comparisons between the ore-forming fluids and their host rocks. The compositions and temperatures of the fluids were evaluated from fluid inclusion data, whereas host-rock temperatures were estimated from vitrinite reflectance measurements.

The ore-forming fluids are characterized by: (1) variable, but generally high salinities (mainly between 15 and 30 wt% NaCl equiv), (2) variable, but generally detectable amounts of bivalent cations (mainly Ca^{2+}), (3) significant concentrations of hydrocarbon species, and (4) high temperatures (mainly between 150° and 250°C). $NaCl/(NaCl+CaCl_2)$ wt ratios in fluid inclusions show a broad district-scale variation: mainly <0.6 for the Jubilee deposit and several showings on Cape Breton Island, and mainly >0.4 for the Gays River and Walton deposits in mainland Nova Scotia. CH_4/higher hydrocarbon ratios of the gas components are greater for the Gays River deposit (3.8-9.7) than the Jubilee deposit (0.7-1.3). Fluid inclusion homogenization temperatures do not show a negative correlation with the distance between the deposits and the central part of the Maritmes basin, as might be expected if the fluids for different deposits were derived from the same source region.

The background temperatures prior to mineralization were estimated from mean vitrinite reflectance (R_o) in host rocks which were relatively far from the deposit, and were probably least affected by the mineralizing events, and from homogenization temperatures of fluid inclusions in preore minerals. These temperatures are in the range of 70° to 155°C, which are significantly lower than those of the ore-forming fluids. The paleogeothermal gradients estimated from the background temperatures and burial depths are ca. 65°C/km. Vitrinite reflectance values in host rocks adjacent to the deposits indicate that these rocks were heated by the mineralizing fluids to variable degrees, but thermal equilibrium between the fluids and rocks was not attained in most cases. This thermal relationship suggests focused and short-lived, rather than pervasive and long-lived fluid flow.

The regional variation of fluid composition and thermal patterns supports a model in which the ore-forming fluids of individual deposits were derived from separate sources; fluid flow was focused along confined conduits and individual mineralizing systems were unconnected hydrologically. Under paleogeothermal gradients of ca. 65°C/km, fluids with temperatures of ca. 250°C could have been generated in sub-basins proximal to the deposits. Sudden release of overpressed fluids from the basal part of the proximal sub-basins, characterized by high flow rate and short duration, is proposed as the mechanism of ore-forming fluid flow.

---

[1] *In:* Economic Geology, v. 93, p. 883-895; Geological Survey of Canada contribution 1996221

[2] Geological Survey of Canada, Quebec Geoscience Centre, P. O. Box 7500, Sainte-Foy, Quebec, Canada G1V 4C7

[3] Department of Earth and Planetary Sciences, McGill University, Montreal, Quebec, Canada H3A 2A7

Modeling fluid-rock interaction during greisenization at the East Kemptville tin deposit: implications for mineralization[1]

W. E. Halter[2, 3], A. E. Williams-Jones[3] and D. J. Kontak

Interaction between a tin-bearing greizenzing fluid and a leucogranitic rock was modeled in order to evaluate the possible role of alteration induced changes in fluid chemistry in cassiterite deposition. The interaction was modeled using simple titration and multiple-pass fluid flow models with the program CHILLER, modified to permit calculations at 450°C and 4.0 kb. The compositions of the mineralizing fluid and the unaltered leucogranite were based, respectively, on analyses of fluid inclusions and whole-rock chemistry, of samples from the East Kemptville greisen-hosted tin deposit, Nova Scotia. The starting fluid contained 4.85 M Cl, 3.7 M Na, 0.53 M Fe, and minor K, Si, F and Sn, and was at a pH of 3.0, while the leucogranite contained 35 wt.% quartz, 29 wt.% albite, 19 wt.% muscovite and 17 wt% K-feldspar. In both models, the calculations show that with increasing alteration, K-feldspar was the first mineral consumed, and that this was followed by replacement of albite by muscovite. With further alteration, muscovite was replaced by topaz and pyrrhotite, and cassiterite precipitated in quartz-topaz rocks. In the most altered rocks, only topaz and quartz are present. These changes accurately reproduce those determined for natural samples at East Kemptville. However, only the multiple-pass fluid flow model predicts the changes in fluid inclusion composition. The multiple-pass fluid flow model quantified changes in fluid composition as a function of its interaction with the wall rock and thus enabled us to assess better the factors that controlled cassiterite precipitation. Important conclusions of the model are that the fluid and the rock equilibrated at each stage of the alteration and the water/rock ratio remained constant across the alteration halo. We further concluded that phases precipitated close to the vein in an earlier stage of the alteration were re-dissolved with evolution of the mineralizing system. In particular, re-dissolution of cassiterite caused an increase in the concentration of $SnCl^+$ in the fluid. As a result, cassiterite saturated at a lower pH, and the chemical potential of $SnCl^+$ increased away from the vein. This could, in turn, explain the low tin grades at East Kemptville. ©1998 Elsevier Science B.V. All rights reserved.

---

[1] *In:* Chemical Geology, v. 150 (1998), p. 1-17

[2] Université de Lausanne, Sciences de la Terre, CAM BFSH 2, CH-1015 Lausanne, Switzerland; Fax: +41 21 692 43 15; e-mail: whalter@cam.unil.ch

[3] Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, Quebec, Canada H3A 2A7

Origin and evolution of the greisenizing fluid at the East Kemptville tin deposit, Nova Scotia, Canada[1]

W. E. Halter[2], A. E. Williams-Jones[3] and D. J. Kontak

The process responsible for greisen-hosted tin mineralization at East Kemptville was investigated using petrographic, chemical, and fluid inclusion analyses of samples from a single deep drillhole (90-1) in the western part of the deposit (Baby zone). Based on their trace element chemistry, the greisens intersected in the hole appear to have all formed from a single leucogranite protolith. Alteration developed as symmetrically zoned halos around central fractures as a result of the interaction of a fluoride-rich orthomagmatic fluid with evolved leucogranite. During alteration, K feldspar was first replaced by albite. With further alteration, albite was replaced by muscovite resulting in the formation of quartz-sericite greisen. Ore minerals are locally present in this zone. Closer to veins, muscovite is replaced by topaz and quartz, producing a quartz-topaz greisen with which the most intense mineralization is associated. This latter greisen is enriched in F, Fe, S, Zn, and Sn, suggesting that these elements were added by the mineralizing fluid. Next to the vein, dissolution of pyrrhotite, sphalerite, and cassiterite characterizes quartz-greisen in which the concentration of ore-forming elements (Sn, Fe, S, F, Zn, Cu) is lower than in the quartz-topaz greisen. Microthermometric measurements of fluid inclusions in quartz from the various alteration zones show that this alteration sequence was formed by only one greisenizing event and that temperature was approximately constant (450°C). The fluid responsible for greisen formation was an NaCl-brine, containing subordinate and variable concentrations of Fe, Mn, and K.

Measured eutectic temperatures of fluid inclusions are lowest in quartz-topaz greisen as a result of an increase in the Fe concentration due to pyrrhotite dissolution. Oxygen fugacity, which was calculated from the CO_2/CH_4 ratio in gases released by crushing fluid inclusion-rich samples, displays a corresponding minimum since pyrrhotite dissolution releases Fe^{2+}. The distribution of pyrrhotite and the fluid inclusion data indicates that pyrrhotite was precipitated close to the vein during early stages of the alteration and reprecipitated farther out as alteration progressed. This suggests that alteration zones moved away from the vein and widened with time.

The salinity of fluid inclusions varies between 27 and 41 wt percent NaCl equiv and increases linearly with increasing distance from the vein, even in the absence of Na-bearing phases. It, therefore, follows that sodium was transported toward the fracture (vein) down a chemical potential gradient. This occurred through compensated infiltration, i.e., a regime in which flow was dominantly parallel to the fracture but individual aliquots of fluid followed complex paths back and forth between the fracture and the rock.

Cassiterite precipitated in quartz-topaz greisen in response to a pH increase of the mineralizing fluid due to its interaction with the wall rock. Other components affecting cassiterite solubility were either constant (temperature) or acted against its precipitation (fo_2 and a_{Cl^-}).

---

[1] *In:* Economic Geology, v. 93, 1998, p. 1026-1051

[2] Present address: Université de Lausanne, Sciences de la Terre, CAM, BFSH 2 CH-1015 Lausanne, Switzerland; email: Whalter@cam.unil.ch

[3] Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, Quebec, Canada H3A 2A7

A study of fluid inclusions in sulfide and non-sulfide mineral phases from a carbonate-hosted Zn-Pb deposit, Gays River, Nova Scotia[1]

D. J. Kontak

This paper reports on a detailed fluid inclusion study of syn-ore (sphalerite, calcite) and post-ore (calcite, fluorite, quartz, barite) mineral phases at the Gays River Zn-Pb deposit (2.4 Mt 8.6% Zn, 6.3% Pb), Nova Scotia, Canada. The deposit is hosted by dolomitized Viséan carbonate rocks, in the basal part of the Windsor Group, that formed during a marine transgression on terrestial clastics of the Tournaisian Horton Group. Mineralization is dominantly of replacement style, with lesser porosity infilling, and mainly occurs in the fore-reef of a carbonate bank, the shallow water equivalent of the laterally extensive, laminated algal and bituminous Macumber Formation. Paragenetically, constant volume dolomitization of the host rock is followed by euhedral, manganiferous dolomite cement, then sphalerite and galena. Syn- to post-ore calcite with trace amounts of barite, fluorite and quartz, occlude the remaining porosity.

Fluid inclusions types include: (1) aqueous, L-rich ± solids, including halite, (2) methane, (3) H_2O-CO_2, (4) monophase L- and V types, and (5) liquid petroleum ± aqueous phase. Type 1 inclusions are most abundant, types 2 and 3 are rare, and type 5 are post ore. Type 4 inclusions are mostly related to post-entrapment changes (e.g. necking). Thermometric data indicate that the mineralizing fluids were high-salinity, $NaCl$-$CaCl_2$-H_2O brines with 20 to 28 wt.% eq. NaCl. Hydrohalite-ice melting relationships indicate considerable variation in the $NaCl/(NaCl+CaCl_2)$ ratio of the fluids (0.2 to 1). Lower salinity fluid inclusions (0-16 wt.% eq. NaCl) are restricted to post-ore calcite and barite. Combined SEM-EDS analysis of decrepitate mounds identify Na, Ca and Mg as the major solute components. Homogenization temperatures (T_h) for all mineral phases range from 70° to 250°C, but ranges of $\leq$10-20°C occur within isolated groups of inclusions. Homogenization data on liquid petroleum inclusions and associated aqueous inclusions in fluorite are 120° to 150°C, whereas three petroleum inclusions in syn- or post-ore calcite have T_h values of 53°, 53° and 167°C.

Bulk crush gas chromatography indicates inclusion fluids contain up to 1.4 mole % combined CO_2 and CH_4 with the most abundant condensable gases in sphalerite and galena. Since the high pressures ($\leq$2000 bars) required to retain this gas as dissolved species in the fluid are incompatible with the local stratigraphy, it is inferred that the gas was either picked up along the fluid path and transported as an immiscible phase or was produced locally in the carbonate bank by thermal degradation of organic material.

The data are interpreted to indicate that a high-temperature ($\leq$250°C), saline (ca. 25 wt.% NaCl) metalliferous fluid migrated into the carbonate bank where it reacted with reduced sulfur generated by thermochemical sulfate reduction and mixed with an equally saline but lower temperature fluid. The variability of the $NaCl/(NaCl+CaCl_2)$ ratio of the fluids suggest contamination by dissolution of the host dolostone; this dissolution may also have provided some of the CO_2 component of the gas. The pressure of the mineralizing environment is constrained at ca. 400 bars by the presence of liquid petroleum, aqueous and methane inclusions and their respective isochoric projections.

The high homogenization temperatures for the mineralizing fluids may reflect the regional setting of the deposit. That is, it is located on the margins of a large stable craton in an area that was structurally active during the Carboniferous and within which widespread thermal disturbances are known. The high temperatures also suggest affinities with the Irish carbonate-hosted base-metal deposits.

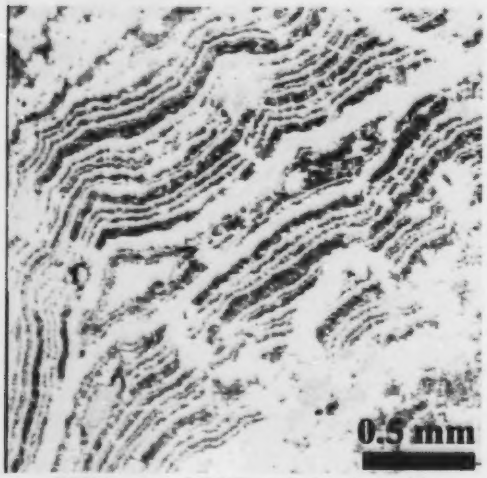
---

[1] *In:* Economic Geology, v. 93, p. 793-817

Geology of the Stirling Zn-Pb-Cu-Ag-Au VMS deposit, southeast Cape Breton, Nova Scotia: reinterpretation of the quartz-talc-carbonate (QTC) rock with implications for mineral exploration[1]

D. J. Kontak

The Stirling VMS deposit is hosted by the Late Hadrynian (680 Ma) Stirling Group, part of the Avalon Terrane of the Canadian Appalachians. Underground mining in the 1930's and 1950's produced 1.06 Mt of 6.3% Zn, 1.5% Pb, 0.8% Cu, 74 g/t Ag and 1.1 g/Au from strongly sheared massive sulphide associated with a quartz-talc-carbonate (QTC) rock. Traditional concepts of a replacement origin for the mineralization were challenged in the 1970's and an exhalative model proposed in which the QTC rock was interpreted as an exhalite. Recent work at Stirling once again suggests that interpretation of the origin and significance of the QTC rock may require modification.



BSE image of QTC rock dominated by magnesite (dark) and dolomite (light).

The Stirling Group, deposited within an intra-arc basin, is dominated by intermediate-felsic volcaniclastics, mafic flows and a sedimentary package of litharenites and siltstone with minor conglomerates, chert and dolostone. The rocks have suffered polyphase, heterogeneous deformation with NE-trending fabrics and structures dominating. At the Stirling deposit, mineralization occurs within a NE-trending, steeply dipping (70-90°S), strongly sheared and altered (carbonate, sericite, epidote, chlorite, silica) felsic volcanic package that is intruded by abundant mafic dykes and the ore is intimately associated with fine-grained, laminated QTC rock. The exposed surface geology indicates that the structural footwall (FW) is a sericite±talc±carbonate±sulphide schist, whereas the structural hanging wall (HW) is a green intermediate tuff with 2 m of laterally discontinuous, well-laminated Sp-Gn-Ccp-Py tectonite intervening. Underground mine plans indicate that: (1) felsic volcanics form the HW and FW; (2) the ore is closely associated with QTC rock; (3) ore horizon intersections are highly variable (≤ 1 to ≤ 10 m); (4) multiple lens of ore occur; and (5) the QTC rock increases at depth to 50 m thickness with $\leq 75\%$ talc. Examination of ddh (1 m intervals) and chip sampling (n=1260) for 6 mine levels indicates no apparent metal zonation with Zn:Pb:Cu of ca. 80:15:5. Detailed study of the QTC rock indicates it: (1) consists of alternating laminae of dolomite-magnesite with magnesite corroding the dolomite (see BSE image) and talc late paragenetically; (2) envelopes clasts of QTC and sulphide; and (3) has multiple episodes of formation. The Stirling deposit is considered to represent a structurally modified VMS deposit with the QTC rock possibly representing a superimposed alteration phenomenon rather than a syngenetic exhalite. However, it is not clear at what time the QTC rock may have formed (i.e. syn- or post-ore). Given this interpretation, a considerable part of the Stirling deposit must have been lost during replacement.

---

[1] *In:* Geological Association of Canada-Mineralogical Association of Canada, Program with Abstracts, v. 23, p. A94

Results of mineral deposit studies at the granite-hosted Dunbrack (Zn-Pb-Cu-Ag) and Kinsac (Ba-F) localities, central Meguma Terrane, Nova Scotia: possible implications for Carboniferous Zn-Pb-Cu-Ag-Ba-F metallogeny in the Meguma Zone[1]

D. J. Kontak, R. J. Horne and K. Ansdell[2]

Two mineralized areas within the ca. 370 Ma Musquodoboit and Kinsac plutons have been examined in order to evaluate the nature and origin of the base-metal (Dunbrack) and barite-fluorite (Kinsac) mineralization, respectively, and determine their implications for regional metallogeny. Although mineralization in both areas is vein-style and of hypogene origin, it is not clear whether the timing of mineralization coincides with emplacement of the host granitic rocks and/or reflects later igneous or hydrothermal events. The setting and nature of the mineralization, as discussed below, indicates that hydrothermal activity might relate to a younger metallogenic event(s) at ca. 300 Ma which may, therefore, have implications for the genesis of Zn-Pb mineralization within the basal Windsor Group (e.g. Gays River).

Base-metal (Zn-Pb-Cu-Ag) mineralization at Dunbrack occurs within a single, 1 m wide quartz vein (100°/62°N) characterized by cockade, comb and crustiform textures with multiple episodes of brecciation. The footwall comprises fine-grained, red felsic dyke (1.2 m), whereas the hanging wall is monzogranite of the Musquodoboit Batholith. The REE profile of a silicified dyke rock sample deviates markedly from the REE signature of the batholith lithologies which possibly suggests a different petrogenesis. Vein mineralogy includes quartz, K-feldspar (Or_{86-100}), muscovite (≤2 wt.% FeO, ≤0.8 wt.% F), kaolinite, Ag-poor galena, chalcopyrite, sphalerite (≤4 wt.% FeO), bornite and an array of Cu, Fe, Pb, Zn sulphides of both hypogene and supergene origin. Pseudosecondary, two-phase (L_{H2O}-V) fluid inclusions in quartz are of equant to negative shape and have uniform T_h values of 138 ± 2°C (n=40; salinities are pending), but trapping conditions are estimated at ≥250°C and ca. 2 kbars. Sulphur isotopes ($\delta^{34}S$; cpy, sph, gal; n=5) range from +2.3 to +6.9‰, except for a single value at -3.1‰, and for T = 200-250°C indicate $\delta^{34}S_{H2S}$= +4.6 to +6.7‰ . $\delta^{18}O$ values for vein quartz (n=9) are uniform at +15.3±1.2‰ and for T = 200-250°C indicate $\delta^{18}O_{fluid}$ = +6 to 8‰. Thus, both ^{34}S and ^{18}O data are consistent with a magmatic fluid. The age of mineralization is estimated at ca. 300 Ma based on $^{40}Ar/^{39}Ar$ dating of altered dyke rock and vein muscovite.

The Kinsac pluton, an extension of the Musquodoboit Batholith to the east, consists of medium-grained, two mica, cordierite monzogranite that contains abundant joints, dykes (aplites, pegmatites) and quartz-tourmaline veins. The dykes are oriented WNW/subvertical, whereas the joints and veins have no preferred trend. Areas of closely spaced shear fractures with horizontal slicken lines define steep NW oriented shear zones. Veins (125-140°/subvertical), dominated by barite±fluorite±quartz and of ≤0.6 m width, are locally abundant throughout the eastern part of the Kinsac pluton in areas where the granite is sheared. The veins are zoned, undeformed and characterized by open-space infilling textures, and are dominated by randomly oriented, bladed barite euhedra (≤6-10 cm) with minor late quartz-fluorite (zoned from clear to purple); fluorite also occurs on joint faces. Barite is Sr poor (n=12; ≤0.35 wt.% Sr) and fluorite (n=5; Sr ≤65 ppm) has slightly concave REE patterns at 10x chondritic abundances with Eu_N/Eu^* = 0.65 and contrasts with thepatterns, abundances and Eu_N/Eu^* exhibited by fluorite from the South Mountain Batholith. $\delta^{34}S$ for barite (n=8) is 13.3 ± 2.3‰, which precludes a magmatic source for sulphur assuming equilibrium SO_4^{2-}-H_2S fractionation, whereas $\delta^{18}O$ for vein quartz (n=3) is 22.1‰, which equates to $\delta^{18}O_{fluid}$ = +13‰ for T = 200°C. Quartz from quartz-tourmaline veins in the pluton has a magmatic $\delta^{18}O$ signature (+12.2‰). Thus, both ^{34}S and ^{18}O data suggest a non-magmatic component was involved in formation of the barite veins with the S probably sourced in Windsor Group evaporates.

---

[1] Abstract, Atlantic Geoscience Society Meeting, Wolfville, Nova Scotia, February 1998; *In:* Atlantic Geology, v. 34, no. 3

[2] Department of Geological Sciences, University of Saskatchewan, 114 Science Place, Saskatoon, Saskatchewan S7N 0W0

We suggest that both sulphide and barite mineralization at the above localities are part of a ca. 300 Ma metallogenic event that also ncludes other centres of mineralization (e.g. Gays River, Walton, Tobeatic Lake, etc.). This metallogenic event coincides with elevated geotherms, magmatic activity (e.g. 312 Ma Wedgeport Granite) and Alleghanian deformation (e.g. SW Nova Scotia) in the Meguma Terrane and suggests that Carboniferous Zn-Pb-Cu-Ag-Ba-F metallogeny is contingent on the conjugation of several geological phenomenon.

^{40}Ar/^{39}Ar dating of ribbon-textured veins and wall-rock material from Meguma lode gold deposits, Nova Scotia: implications for timing and duration of vein formation in slate-belt hosted vein gold deposits[1]

D. J. Kontak, R. J. Horne, S. Harnish[2,3]*, D. Archibald*[2] *and J. K. W. Lee*[2]

Results of fifteen ^{40}Ar/^{39}Ar age spectra for whole-rock argillite samples collected from within and adjacent to veins from eight Meguma gold districts in the Meguma Terrane of southern Nova Scotia are presented. The samples give excellent plateau ages (i.e. concordance of plateaux, correlation and integrated ages) that range from ca. 379 to ca. 403 Ma and there is no apparent correlation of age with bulk rock composition (K_2O, Al_2O_3) or sampling localities. In addition, apparent ages for samples from a district are similar within analytical error, except for one deposit, and there is no difference for samples from within ribbon-textured veins versus samples collected outside of the gold districts (i.e. in areas free of quartz veining). The results of this work compare well to previous whole rock ^{40}Ar/^{39}Ar dating of Meguma Group samples and we concur with previous workers that the range in dates (i.e. 380 to 410 Ma) reflects diachronous cooling of the area through the intracrystalline retention temperature for argon in mica (i.e. ca. 300-350°C). However, with respect to the vein samples, there is a marked difference between the ^{40}Ar/^{39}Ar ages of vein-hosted whole-rock samples and hydrothermal minerals (amphibole, muscovite, biotite) from the same deposits previously dated, which indicates that whole-rock samples have retained their metamorphic ages and have not been reset by the later hydrothermal event responsible for vein formation, despite being incorporated within the high-temperature fluids (ca. 400-450°C). This discrepancy in ages indicates that the wall rocks and veins were in thermal disequilibrium, as the vein temperatures were well above that required to cause diffusion of argon out off mica phases within the whole-rock samples, and implies therefore that the fluids must have been derived from depth. The results have the following important implications for models of vein formation: (1) vein formation was rapid and is consistent with models of hydrofracturing due to fluid overpressure, and (2) the vein-forming fluids were derived from depth and cannot have been produced by a lateral secretion processes whereby fluids and gold are derived from the Meguma Group.

---

[1] *In:* Canadian Journal of Earth Sciences, v. 35, p. 746-761

[2] Department of Geological Sciences, Queen's University, Kingston, Ontario, Canada K7L 3N6

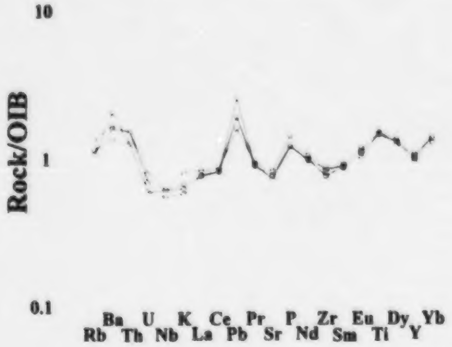
[3] Present address: Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8

Petrology of Late Cretaceous (ca. 90 Ma) lamprophyric dykes from north Greenland[1]

D. J. Kontak, S. M. Jensen[2], J. Dostal[3], D. A. Archibald[4] and K. Kyser[4]

Mafic dykes cutting deformed lower Paleozoic sedimentary rocks of the Franklinian Basin have been sampled north of Frigg Fjord and Harebugt just off Frederick E. Hyde Fjord, northern Greenland. The dykes, forming the southern part of an extensive Cretaceous dyke swarm, can be related to a mantle plume that was responsible for extensive Cretaceous-Tertiary magmatism and basin formation in northern Greenland.

Normalized plot of most primitive dyke rocks.



The dykes (1-15 m wide, 10s-100s m long) outcrop as massive, fine-grained rocks with chilled margins and, in some cases, vesicular textures infilled with white to rusty brown carbonate±Py. Dyke orientations vary from 135-155°/50-90°SW at Frigg Fjord to 060-080°/60-90°S at Harebugt Fjord. Petrographically the dykes are characterized by ophitic textures and are dominated by Opx-Pl-Ilm-Ap±Ol±Bt±Kf; both Cpx and Pl are strongly zoned and Ilm varies from equant to skeletal. A single dyke sample containing abundant granophyre surrounding zoned calcic plagioclase represents the most evolved composition. Alteration varies considerably (i.e. 0.05 to 6.6 wt.% CO_2) such that pristine to extensively altered material is represented; secondary minerals are Ms, Chl, Ab, Kf (Or_{93-100}), Fe-Mg-Mn carbonate, Fe oxides, iddingsite, Srp, Py. Mineral chemistry is as follows: Pl zoned from core (An_{74-55}) to rim (An_{55-35}) with ≤1.5 wt.% BaO, but An_{0-20} in granophyres. Cpx is titaniferous augite with ≤4.1 wt.% TiO_2 and mg = 0.70±0.04 with substitution following Si $\rightleftharpoons$ Ca+Al+Ti (r=0.98). Rare Opx has mg = 0.69±0.05 and is always corroded, whereas for Ol mg = 0.31 to 0.69 and single grains are strongly zoned (Fo_{69-35}). Bt has mg = 0.33 ± 0.03, is both F and Cl poor, and has 5 wt.% TiO_2. Major and trace element chemistry for least evolved samples (anhydrous, recalculated to 100%) are uniform at: (1) 45-47 wt.% SiO_2, 4.1 wt.% TiO_2, 15 wt.% Fe_2O_3(T), 2.8 wt.% Na_2O, 0.9 wt.% K_2O, 0.8 wt.% P_2O_5, and ≤0.03 and≤0.08 wt.% Cl and F, respectively; (2) trace elements (ppm) are Rb=35, Sr=500, Ba=5600, Zr=220, Nb=28, Ni=45, Cr=75, V=330; (3) REE are enriched (La_N=90, $\sum$14REE=175 ppm), strongly fractionated [$(La/Lu)_N$=7] and Eu/Eu*=0.96. Both major and trace element variations reflect crystal fractionation dominated by Cpx+Pl+Ilm. Tectonic discriminant diagrams, based on both whole-rock and Cpx chemistry, and the LILE, HFSE and REE data are generally consistent with a within-plate setting, whereas OIB-normalized spidergram plots are close to unity (see Figure). Thus, both the chemical and mineralogical data are consistent with features of the lamprophyric association. $^{40}Ar/^{39}Ar$ dating of whole-rock material indicates an age of 90 ± 5 Ma for the magmatism.

---

[1] *In:* Geological Association of Canada-Mineralogical Association of Canada, Program with Abstracts, v. 23, p. A94

[2] Geological Survey of Denmark and Greenland, Thoravej 8, DK-2400 Copenhagen NV, Denmark

[3] Department of Geology, St. Mary's, University, Halifax, Nova Scotia B3H 3C3

[4] Department of Geological Sciences, Queen's University, Kingston, Ontario K7L 3N6

Aqueous and liquid petroleum inclusions in barite from the Walton Deposit, Nova Scotia, Canada: a Carboniferous, carbonate-hosted Ba-Pb-Zn-Cu-Ag deposit[1]

D. J. Kontak and D. F. Sangster[2]

The Walton Ba-Pb-Zn-Cu-Ag deposit, with an historical (1941-1978) production of 4.4 Mt of barite and 0.36 Mt of massive sulfide ore, is hosted by sideritized, Viséan carbonates of the Macumber Formation which forms the basal member of the marine Windsor Group in southern Nova Scotia. The stratabound mineralization occurs as massive barite which gives way to barite and sulfide mineralization at depth; locally, mineralization transects bedding and may occur within the underlying terrestial clastics of the Tournaisian Horton Group. Barite occurs in a variety of forms (massive to bladed, fine- to coarse-grained) and colors (white, red, orange and shades of these) and overlaps the deposition of sulfide minerals.

All barite types are characterized by the presence of abundant aqueous and liquid petroleum fluid inclusions that are of dominantly equant shape, of primary and secondary origin and ≤ 100-150 μm size. Inclusions are classified as: (1) L- and V-rich aqueous with rare solid phases; (2) mixed CO_2 and CH_4 (rare); and (3) liquid petroleum with rare bitumen. It is not possible to establish a chronology for the different fluids and all types may in fact be closely related temporally and spatially. The occurrence of three phase aqueous-petroleum inclusions, indicative of heterogeneous trapping, indicates contemporaneity of the aqueous and petroleum inclusions. The aqueous inclusions are dominated by high-salinity types (20-28 wt.% eq. NaCl), but intermediate- and low-salinity types also occur. Observations of first melting (eutectics at -55°C and -35°C) and final melting (ice and hydrohalite) indicate fluid compositions varied in terms of $NaCl/(NaCl+CaCl_2)$ (≤ 0.1 to 1.0) and $NaCl/(NaCl+MgCl_2)$ (0.2 to 0.84) ratios. Preliminary SEM/EDS analysis of decrepitate mounds confirms the presence of Na, Ca and Mg and also indicates K, Fe and Mn in solution. The lack of clathrate phases suggests that, if present, condensed gases (e.g., CH_4, CO_2) occur in only minor to trace amounts in aqueous inclusions. Homogenization temperatures cover a broad range with maximum temperatures of ca. 300°C.

Liquid petroleum inclusions, with a blue-white color under UV light, occur in isolated populations with uniform L:V ratios characterizing a particular group. Homogenization temperatures range from ca. 100° to 300°C, similar to the range for aqueous inclusions, but within a group a much narrower range is recorded. The high homogenization temperatures and rare occurrence of bitumen in the inclusions predicates rapid, post-entrapment cooling of the area (i.e., within a few Ka) otherwise degradation of the petroleum would have occurred. The $\delta^{34}S$ signatures of sulfides at Walton suggest mineralization occurred in the presence of liquid petroleum with the petroleum causing reduction of aqueous sulfate to H_2S.

Collectively the fluid inclusion data indicate mineralization occurred at ambient conditions of 250° to 300°C and pressures of ca. 400 bars, as constrained for different inclusion types. The liquid petroleum is considered to have been generated by thermogenic processes via interaction of the heated, highly-saline mineralizing fluid with organic-rich beds within the Horton Group (Horton Bluff Formation) and subsequently entrained as an immiscible phase within the aqueous fluid. Generation of the hydrothermal petroleum at Walton is analogous to the present day occurrence of liquid petroleum vented from black smokers on the ocean floor (e.g. Guaymas Basin).

---

[1] *In:* Economic Geology, v. 93, p. 845-868

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8

Geology of the B baseline zone, Walton Cu-Pb-Zn-Ag-Ba deposit, Nova Scotia, Canada[1]

D. F. Sangster[2], M. D. Burtt[3] and D. J. Kontak

The Walton Ba-Cu-Pb-Zn-Ag deposit, Nova Scotia (production 4.5 million metric tons (Mt) >90% $BaSO_4$ and 412,850 t @ 0.52% Cu, 4.28% Pb, 1.29% Zn, and 350 g/t Ag), is hosted by Viséan age carbonate rocks of the Macumber Formation and its associated breccia. The Macumber Formation in the Walton area is divided into two units, the lower Macumber, a laminated carbonate unit 9 to 12 m thick and the upper Macumber, a synsedimentary carbonate slump breccia that forms two mounds up to 21 m thick.

Outside the immediate mine area the carbonate is either limestone or dolostone: the Macumber Formation surrounding the deposit has been altered to manganiferous siderite. Although three textural type of siderite are recognized, little variation in bulk chemical composition is evident among them.

Minerals were deposited in the sequence: barite, pyrite-marcasite, sphalerite, galena, tennantite, chalcopyrite, and (para)rammelsbergite. Each mineral replaces earlier minerals to varying degrees.

Based on barite and metal content two main ore types are defined. Type I, with a bulk composition of 0.3 percent Cu, 2.5 percent Pb, 0.2 percent Zn, and 31.2 percent $BaSO_4$, comprises barite and variable sulfide contents. Type II, comprised of sulfides only, has a composition of 0.5 percent Cu, 0.5 percent Pb, 0.1 percent Zn, 51 g/t Ag, and no barite. Type I ore forms a roughly conformable sheet which straddles the upper Macumber-lower Macumber contact and contains lenses of Pb- and Cu-rich ore. Type II ore is most commonly associated with the upper Macumber mounds when it forms large pods which cut the type I ore zone. Type II ore also occurs within the underlying Horton Group sandstones but only when the upper Macumber mounds have developed. There is also a stratigraphic zonation in metal content inasmuch as all metals are higher, on average, in the lower Macumber relative to the upper Macumber.

The host stratigraphy is steeply dipping and faulted and both features are considered to be postore events. Karsting, which also postdates mineralization and probably folding, has removed portions of the stratigraphic upper parts of the deposit. The cavities produced by this process are now partially filled with sand and limestone breccia.

---

[1] *In:* Economic Geology, v. 93, 1998, p. 869-882

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8; e-mail: dsangster@easyinternet.net;
Present address: 2335 Russvern Drive, North Gower, Ontario, Canada K0A 2T0

[3] P. O. Box 156 North Gower, Ontario, Canada K0A 2T0

A genetic model for mineralization of Lower Windsor (Viséan) carbonate rocks of Nova Scotia, Canada[1]

D. F. Sangster[2], M. M. Savard[3] and D. J. Kontak

This paper summarizes and integrates some of the results of a three-year research project on the source, path, and timing of fluid movement within and between sub-basins in Nova Scotia, lower Carboniferous (Viséan) carbonates, and the relationship of these fluids to base metal mineralization. The Kennetcook, Shubenacadie, and Musquobodoits sub-basins in central mainland Nova Scotia and the River Denys sub-basin on Cape Breton Island are, excellent examples of platformal onlapping sedimentation of the larger Maritimes basin. Within each of these sub-basins, one base metal deposit was selected for detailed research. Prior to mineralization, potential host rocks in the four sub-basins contained substantial zones of porosity as a result of various processes. For example, at Walton, synsedimentary breccias provided abundant (open space in the otherwise fine-grained, tight Macumber Formation carbonates. The lower grade mineralization at Gays River was deposited in primary porosity within reefal facies of the Gays River Formation. Both overpressuring and gravity-driven flow have been proposed and tectonic conditions prevalent during the time of mineralization provide permissive support for either process, especially in the Walton and Gays River areas. Tectonic breccias, developed in Macumber Formation carbonates during movements associated with the Ainslie detachment, are the main host of the Jubilee deposit. In all three deposits, however, open-space filling was accompanied by widespread replacement of the host carbonate. With increasing burial, Windsor Group limestones were selectively sideritized at Walton, totally dolomitized at Gays River, and simply lithified at Jubilee. Preore burial temperatures reached 70°C at Walton, 135°C at Gays River, and 65°C at Jubilee.

Timing of mineralization has been determined by a variety of methods indicating that ore fluids entered the Gays River area at about 320 to 300 Ma, the Walton area at 333 to 307 Ma, and the Jubilee area at 330 to310 Ma. Given the uncertainty in the dating methods used, these data are interpreted to indicate overlapping mineralization among the three areas.

The distribution of-deposits and occurrences in the Kennetcook and Shubenacadie-Musquodoboit sub-basins suggest a northerly source of fluids for deposits in these sub-basins; the direction of fluid flow in the River Denys sub-basin remains speculative. Evaporated seawater was the most likely original source of ore fluids, but these were modified during burial by halite dissolution and by reaction with underlying siliciclastic aquifers.

Temperatures of ore-stage deposition decrease from Walton (median ~200°C, range 100-300°C), to Gays River (median ~140°C, range 80°-220°C),and to Jubilee (median ~140°C, range 80°-220°C). The high-temperature, high-salinity ore-forming fluid is interpreted to have entered the host rocks and mixed with, and was cooled by, an ambient low-temperature, high-salinity fluid. Several possible sources of the extraordinary heat in the primary fluid are proposed and include an underlying basalt plate, high. heat-production granites, an increase in geothermal gradient caused by coeval extension, or a combination of these.

Ore fluids appear to have been primarily complex $NaCl\text{-}CaCl_2\text{-}KC1\text{-}MgCl_2\text{-}FeCl_2$, aqueous solutions with lesser amounts of light gases such as CO_2 and CH_4. Hydrocarbons were present in ore-stage fluids at both Walton and Jubilee and more than 99.9 percent of the hydrocarbon occurs as liquid petroleum. Given the high temperatures of these deposits, the presence of liquid petroleum indicates a short-lived mineralizing system, probably on the order of a few hundred thousand years.

---

[1] *In*: Economic Geology, v. 93, 1988, p. 932-952; Geological Survey of Canada contribution 1997273

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Canada K1A 0E8; e-mail: dsangster@easyinternet.net; present address: 2335 Russvern Drive, North Gower, Ontario, Canada K0A 2T0

[3] Geological Survey of Canada, Centre Géoscientifique de Québec, P. O. Box 7500, Sainte-Foy, Quebec, Canada G1V 4C7

A clear relationship with underlying basement lithologies is indicated by the sub-basin-specific character of Pb and Sr isotopes in ore-stage minerals, suggesting that ore fluids leached metals directly from basement rocks, or more likely, from sediments derived from it.

Isotopic data indicate that sulfur at Walton, Gays River, and Jubilee was derived from the same source, probably deeply circulating sulfate-rich brines. The data also suggest that sulfate reduction at Gays River must have taken place away from the deposit area whereas data from the Walton and Jubilee deposit suggest *in situ* thermochemical reduction of sulfate by hydrocarbons.

Compared with other Carboniferous, carbonate-hosted deposits in Newfoundland and Ireland, those in Nova Scotia are considerably younger, relative to their host rocks; are more inhomogeneous, in terms of $^{206}Pb/^{204}Pb$ ratio than those in Newfoundland but compare well with those in Ireland; posses Pb isotope compositions which plot above the Stacey-Kramer growth curve whereas those in both Newfoundland and Ireland plot below it; and exhibit fluid inclusion temperatures and salinities comparable with those of Newfoundland deposits but many are hotter and most are more saline than those of deposits in Ireland. Collectively, the following common parameters are suggested for deposits in all three localities: (1) formation of most, if not all, by replacement of lithified carbonate rocks; (2) derivation of metals from directly underlying basement rocks, resulting in the control of ore-lead isotope compositions according to age and composition of basement lithologies; and (3) ore-stage mineralization at temperatures higher than those typical of Mississippi Valley-type deposits but lower than those typical of sedimentary exhaltive deposits.

Sub-basin-specific Pb and Sr sources in Zn-Pb deposits of the Lower Windsor Group, Nova Scotia, Canada[1]

D. F. Sangster[2], M. M. Savard[3], and D. J. Kontak

Several carbonate-hosted lead-zinc deposits, displaying replacement and/or open-space-filling textures occur in the Lower Windsor Group (Viséan) of Nova Scotia, Canada. Many of these deposits are distributed within four sub-basins (Kennetcook, Musquodoboit, Shubenacadie and River Denys) over a distance of about 300 km.

Lead isotope ratios in galena from eight deposits and strontium isotope ratios in ore-stage calcite from two deposits and in sphalerite from one deposit collectively indicate derivation of these elements directly from sources specific to each sub-basin. These sources were identified as immediately underlying basement components or sedimentary rocks derived from them.

---

[1] *In:* Economic Geology, v. 93, 1998, p. 911-919; Geological Survey of Canada contribution 1997254

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8; corresponding author: e-mail: dsangster@easyinternet.net; present address: 2335 Russvern Drive, North Gower, Ontario, Canada K0A 2T0

[3] Geological Survey of Canada, P. O. Box 7500, Sainte-Foy, Quebec, Canada G1V 4C7

δ^{13}C-δ^{18}O-^{87}Sr/^{86}Sr covariations in ore-stage calcites at and around the Gays River Zn-Pb deposit (Nova Scotia, Canada) - evidence for fluid mixing[1]

M. M. Savard[2] and D. J. Kontak

The δ^{13}C-δ^{18}O-^{87}Sr/^{86}Sr variations around carbonate-hosted deposits can in theory help characterize ore-stage gangue minerals and discriminate between single fluid or two-fluid mixing models during mineralization. This paper reports on the combined use of δ^{13}C-δ^{18}O-^{87}Sr/^{86}Sr data in dolostone within the Gays River deposit and up to 30 km around it. The deposit, at the southern margin of the Maritimes basin, is hosted in carbonate banks of the Gays River Formation, a unit of the Viséan Lower Windsor Group in Nova Scotia. A previous δ^{13}C-δ^{18}O study restricted to the Gays River deposit (and independent from an ^{87}Sr/^{86}Sr investigation) had previously led to the conclusion that a single brine was responsible for mineralization.

The present isotopic investigation was governed by the paragenetic succession which includes presulfide dolomite, synsulfide calcites - both uniform and zoned under cathodoluminescence, and postsulfide calcite uniform under cathodoluminescence. Results for presulfide dolomite (avg δ^{13}C=+3‰, δ^{18}O$_{V\text{-}PDB}$=-6‰, and ^{87}Sr/^{86}Sr=0.7080) plot near the normal marine isotopic ratios, whereas postsulfide calcite shows slightly more radiogenic ^{87}Sr/^{86}Sr ratios (avg=0.7090). At the deposit, isotopic results for calcite associated with the high-grade sulfide zone cluster around a δ^{18}O$_{V\text{-}PDB}$ of -17.0 per mil and an ^{87}Sr/^{86}Sr of 0.7120, and clearly characterize the mineralizing system. Regional C, O, and Sr isotope data are similar to those at the deposit and indicate therefore a regional flushing of the Gays River Formation by fluids of the mineralizing system.

The overall isotopic variation through time from pre- to syn- then postsulfide conditions in the δ^{18}O-^{87}Sr/^{86}Sr, δ^{13}C-δ^{18}O and δ^{13}C-^{87}Sr/^{86}Sr diagrams is interpreted to be similar for pre- and postsulfide conditions, marked by a warm, slightly radiogenic parent brine. This chemical system was disturbed by a much more radiogenic and high-temperature fluid during mineralization. Although most of the mineralizing trend can be explained either by a single-brine model or a mixing brine model, the mixing model allows for a much simpler evolution if the suite of conditions - on a regional basis - is considered through time.

"Show me your δ^{18}O-^{87}Sr/^{86}Sr profile, and I will tell you what you drink!" (adapted old Spanish proverb).

---

[1] *In:* Economic Geology, v. 93, p. 818-833; Geological Survey of Canada contribution 1996124

[2] Geological Survey of Canada-Quebec, Centre Géoscientifique de Québec, P. O. Box 7500, Sainte-Foy, Quebec, Canada G1V 4C7; e-mail, msavard@gsc.nrcan.gc.ca

Glacial retreat and relative sea-level changes in Maritime Canada[1]

R. R. Stea and G. B. Fader[2]

The Scotian Shelf End Moraine Complex, formed between 18 - 15 ka at the tidewater margin of a glacier centered over Nova Scotia (Scotian Ice Divide). Isostatic rebound from a more extensive ice sheet at the Late Wisconsinan (Escuminac Ice Centre) helped stabilize this ice margin. These moraines are found between 170 - 85 m below sea level. Depth variation can be attributed to differential uplift and proximity to post-Scotian Phase late-glacial ice centres, assuming that the moraines all formed at the same critical buoyancy depth. Raised marine deposits formed between 14 - 12.5 ka following rapid ice retreat in the Gulf of Maine and Bay of Fundy. Post-glacial emergence patterns over Maritime Canada are controlled by rates of glacier retreat and variations in ice loads over the region. AMS dating of basal lake sediments and buried organic sections show that glaciers persisted over mainland Nova Scotia until 11 ka, several thousand years after ice was removed from the Gulf of Maine and the Bay of Fundy. Marine limits decline towards local centres of ice flow, reflecting diachronous emergence under low-profile or smaller ice caps. At 11.6 ka, relative sea-level along the inner Scotian Shelf of Nova Scotia stood at -65 m below sea level. A shoreline developed, marked by the abrupt transition from moraines and drumlins to truncated landforms and muted topography, terraces and cliffs, and deltaic deposits. In contrast to earlier, tilted emerged shorelines, this inner shelf lowstand shoreline is relatively undeformed and can be traced along the entire length of eastern mainland, Nova Scotia. Recently collected seismic reflection data from Browns Bank show prominent bank-edge deltas with upper layout contacts between 40 - 70 m. Terraces, clinoforms and significant erosional unconformities on glaciomarine sediments below 90 m may also indicate greater sea-level lowering in the offshore banks and the Bay of Fundy. The patterns of post-glacial relative sea-level change in Nova Scotia and Maine are similar, if emergence under late-melting ice is considered. The high amplitude and short wavelength of relative sea-level curves are not consistent with geophysical models of sea-level change that emphasize slow-response mantle deformation.

---

[1] Presented at Geological Survey of America, 33rd annual northeastern meeting, Portland, Maine, March 1998; also presented at Geological Association of Canada-Mineralogical Association of Canada meeting, Quebec, May 1998

[2] Bedford Institute of Oceanography, Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2

Deglaciation of Nova Scotia: stratigraphy and chronology of lake sediment cores and buried organic sections[1]

R. R. Stea and R. J. Mott[2]

The deglaciation of Nova Scotia is reconstructed using the AMS-dated chronology of lake sediments and buried organic sections exposed in the basins of former glacial lakes. Ice cleared out of the Bay of Fundy around 13.5 ka, punctuated by a brief readvance ca. 13-12.5 ka (Ice Flow Phase 4). Glacial Lake Shubenacadie (1) formed in central Nova Scotia, impounded by a lobe of ice covering the northern Bay of Fundy outlet. Drainage was re-routed to the Atlantic Ocean until the Fundy outlet became ice free after 12 ka. When this lake drained, bogs and fens formed on the lake plain during climatic warming. Organic sediment (gyttja) began to accumulate in lake basins throughout Nova Scotia. Glacierization during the Younger Dryas period (ca. 10.8 ka) resulted in the inundation of lakes and lake plains with mineral sediment. The nature and intensity of this mineral sediment flux or "oscillation" varies from south to northern regions. Southern lakes simply record changes in total organic content whereas northern lakes, where most buried peat sections are found, feature a thick inorganic sediment layer. Glacial ice or permanent snow cover and seasonal melting are essential in the formation of this mineral sediment layer; both to provide the water source for erosion, and to prevent plant re-colonization and landscape stabilization. Some northern lakes do not appear to record the Younger Dryas event, with organic accumulation starting around 10 ka. During the Younger Dryas, fine and coarse-grained deposits were deposited in Glacial Lake Shubenacadie (2) and other lowland areas at elevations similar to former (12 ka) lake levels, impounded by re-invigorated residual ice caps and permanent snow/aufeis.

---

[1] *In:* Géographie Physique et Quaternaire 1998, v. 52, p. 3-21

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

Using whole rock geochemistry to locate the source of igneous erratics from drumlins on the Atlantic Coast of Nova Scotia[1]

R. R. Stea and G. Pe-Piper[2]

Whole rock geochemistry has been determined for erratics from the surface Lawrencetown Till in two drumlins on the Atlantic coast of Nova Scotia. The geochemical data, particularly trace element composition, allows source rocks to be identified more precisely than by traditional petrographic microscopy. A drumlin near Lunenburg contains erratics of Neoproterozoic arc-related plutonic rocks and basalts that outcrop only in a small area near Parrsboro in the Cobequid Highlands. Some associated erratics of granite precisely match a small late Devonian pluton in the same area and other granites and rhyolite could also be derived from late Devonian rocks in the same area. The type section of the Lawrencetown Till contains different Neoproterozoic plutonic rocks of a type found in the eastern Cobequid Highlands, together with a distinctive late Devonian granite with sodic amphiboles that is restricted to a small area near the Debert River. Both these source areas indicate a southward flow of ice (Escuminac Phase) depositing the Lawrencetown Till, in contrast to earlier southeastward-flowing ice (Caledonia Phase) which deposited the Hartlen Till that forms the core of the drumlin. Drumlins in Nova Scotia are complex palimpsest landforms which formed by till-accretion, and evolved in surface form throughout multiple flow events.

---

[1] *In:* Boreas, v. 28, p. 1-23

[2] Department of Geology, Saint Mary's University, Halifax, Nova Scotia, Canada B3H 3C3

Wisconsinan glacial and sea-level history of Maritime Canada and the adjacent continental shelf: a correlation of land and sea events[1]

R. R. Stea, D. J. W. Piper[2], G. B. J. Fader[3] and R. Boyd[3]

The Wisconsinan glacial history of Maritime Canada records the interaction of land-based glaciers with the sea, which dissects the region along the deep embayments of the Bay of Fundy and the Laurentian Channel. Ice centres, collectively termed the Appalachian Ice Complex, shifted in a clockwise manner across the varied bedrock terranes of the region, producing cross-striated bedrock outcrops and compositionally distinct till sheets on land. Based on provenance, offshore glacial sediments can be correlated to their terrestrial counterparts, hence establishing crucial land-sea links in the glacial record. Five glacier flow events have been recognized.

During the Caledonia Phase in the Early to Mid Wisconsinan, ice from eastern Appalachian upland sources crossed Nova Scotia and extended to the continental shelf edge where a calving margin was established. Slumping at this margin produced proximal-wedge-shaped bodies of diamicton that interfinger with glaciomarine sediments. The Caledonia Phase glacier retreated during the Mid Wisconsinan to the inner Scotian Shelf. During the Escuminac Phase in the Late Wisconsinan (22-19 ka) an ice centre formed over the Magdalen Shelf (Escuminac Ice Centre) and transported large quantities of local red-bed material southward to the outer shelf/slope margin. This glacier retreated about 18 ka to a tidewater margin at Sable Island Bank and Banquereau. Sea level during this time period was falling as a result of isostatic recovery from earlier Escuminac Phase maximum ice loads. Just after 18 ka, ice wasted back across the mid-shelf basins to the tidewater margin of the Scotian Shelf end moraine complex and was stabilized by falling sea levels. Esuminac ice was reorganized into the Scotian Ice Divide (Scotian Phase) over mainland Nova Scotia and the continental shelf south of Cape Breton Island. Between 15 and 13 ka another period of glacier retreat ensued, and the margin settled close to the present day land areas. Between 13 and 12.5 ka an ice margin was established from local terrestrial ice centres in northern Nova Scotia (Chignecto Phase) into the Bay of Fundy and just beyond the present day Atlantic coast. Responding to increasing climatic warming, these smaller glaciers dissipated and their margins retreated landward. A sea-level lowstand of -65 m on the inner shelf occurred ca. 11.7 ka. Isolated terrestrial remnants of Chignecto Phase glaciers were re-activated as a result of cooling during the Collins Pond Phase (Younger Dryas) ca. 10.8 ka.

Enhanced ice rafting, evident in the North Atlantic deep oceanic record, appears to correlate with periods of glacier retreat in the Appalachian Ice Complex. During melting and sea-level rise, both the quantity and thickness of icebergs increased due to grounding-line retreat within the Magdalen Shelf, thereby increasing the net flux of hematite-stained quartz to the North Atlantic.

---

[1] *In:* Geological Society of America Bulletin, v. 110, no. 7, p. 821-878

[2] Geological Survey of Canada (Atlantic), P. O Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2

[3] University of Newcastle, New South Wales, 2308, Australia

Appendix 1

Mining Industry Activity in Nova Scotia, 1997

Mining Industry Expenditures

Investment by the mining industry in Nova Scotia is monitored by means of annual surveys of all companies having operations or activity in the province. Aggregate producers are not included in this survey. The surveys are carried out by the Nova Scotia Department of Natural Resources (DNR) jointly with Natural Resources Canada (Minerals and Metals Sector - Minerals and Mining Statistics Division), and Statistics Canada (Investment and Capital Stock Division). The Mines and Energy Development Division of DNR actively participates in the Annual Survey of Canadian Mineral Exploration Expenditures and the Annual Survey on Exploration Development, Capital and Repair Expenditures.

Preliminary figures indicate exploration expenditures in 1997 remained at roughly the same level as 1996 (Table 1.1). Diamond-drilling, however, was up significantly in 1997 over 1996. Capital expenditures at existing mines were down slightly in 1997 from 1996 and repair and maintenance expenditures were down moderately.

Mining Leases

There were no Mining Leases issued during the year.

Mining Permits

There were no Mining Permits issued.

Production Information from Mines, Quarries and Other Operations

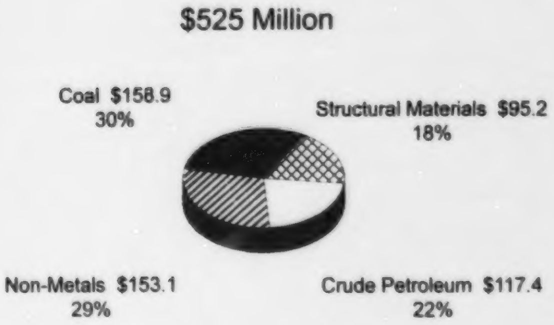
In 1997, the estimated total value of Nova Scotia's mineral production, including secondary mineral processing and crude petroleum, totalled $525 million (Fig. 1.1), a decrease of 16% from the year before. This decrease was due largely to lower outputs of crude petroleum and coal. Excluding petroleum, the total value of Nova Scotia's mineral production totalled $407 million, down 5% from 1996's figure of $428 million. Coal sales dropped approximately 16% in 1997 to 2.7 million tonnes from 1996's figure of 3.2 million tonnes as production problems plagued the

Table 1.1. Mining industry expenditures in 1996 and 1997.

		1996	1997[1]
Mineral Exploration Expenditures (field plus overhead)[2]		$6,892,000	$6,726,000
Exploration diamond-drilling[2]		13 895 m	26 487 m
Exploration drilling - other[2]		1 865 m	1 440 m
Mineral Development Expenditures (field plus overhead)		$6,036,266	$5,483,000
Capital and Repair Expenditures at Mining Establishments			
Construction:	Capital	$ 7,730,000	$3,032,700
	Repair	$ 2,600,000	$438,754
Machinery and Equipment	Capital	$29,060,000	$30,894,805
	Repair	$33,080,000	$24,610,000

[1] preliminary

[2] includes deposit appraisal



Includes secondary mineral processing where applicable

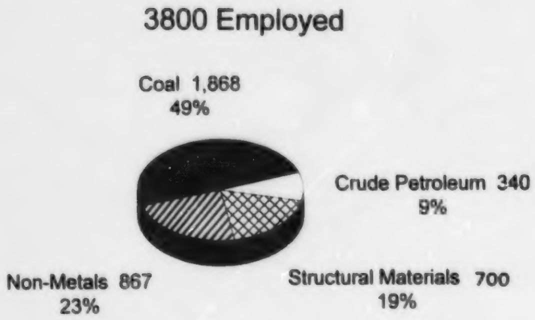
Figure 1.1 Value of mineral production by commodity group.

province's largest coal mine, the Cape Breton Development Corporation's Phalen Colliery. Employment in Nova Scotia's mineral industry totalled roughly 3800 persons (Fig. 1.2), a 5% decrease from the year before (Fig. 1.3).

On a more positive note, Nova Scotia's industrial minerals producers had another good year in 1997, producing more than 21 million tonnes of industrial minerals worth an estimated $248 million. 1997 was a record year for Nova Scotia gypsum shipments with a total of 7.09 million tonnes shipped, mainly to wallboard plants along the U.S. Eastern Seaboard. This just surpasses the old record of 7.04 million tonnes set in 1994. Seventy percent of all gypsum imported into the United States in 1997 came from Nova Scotia. Nova Scotia is Canada's largest gypsum producer, accounting for more than 80% of the country's total production.

Salt shipments rose 17% in 1997 over 1996 to 1.3 million tonnes. Cement sales, however, were down 28% from 1996. Overall, aggregate products (crushed stone, sand and gravel) increased by 9% in 1997 from the year before. Crushed stone production rose by 28% while sand and gravel production dropped by 20%. The increase in crushed stone output can be largely attributed to construction of the Cobequid Pass (Highway 104 western alignment).

Although petroleum is included in the overall value of Nova Scotia's mineral production, this appendix focuses on the non-petroleum sectors of the industry (Table 1.2), providing a description of each mine site. Tables 1.3 to 1.5 provide more detailed information on production of different commodities. Site locations are shown on the accompanying maps, Figures 1.4 and 1.5. Production data are for the calendar year 1 January 1997 to 31 December 1997.



Includes secondary mineral processing employment where applicable

Figure 1.2. Employment by mineral commodity group.

Metal Mines and Gold Mines

Metal Mines

There were no producing metal mines in 1997.

Gold Mines

There were no producing gold mines during the year.

Coal Mining Operations

During 1997, there were two underground coal mines and seven surface coal mines operating in the province. Table 1.3 summarizes production information for the coal mines. The summaries below give brief details of the underground and surface coal mines operating in Nova Scotia.

Underground Coal Mines

CAPE BRETON DEVELOPMENT CORPORATION

Manager(s): B. MacDonald, General Manager, Phalen Colliery
T. Isaacs, General Manager, Prince Colliery
Address: P. O. Box 2500
Sydney, N. S. B1P 6K9

Raw Coal
Production: 2,562,711 tons (2 324 876 tonnes)
Employees: 1,743

Table 1.2. Summary of Nova Scotia mineral production, 1996 and 1997.

DESCRIPTION	1996 VALUE '000$[1]	1996 EMPLOYMENT*	1997 VALUE '000$[1]	1997 EMPLOYMENT*
METALS				
Gold				
Total metals	0[2]		0[2]	
INDUSTRIAL MINERALS				
(Non-Metals)				
Anhydrite	2,193		2,148	
Barite	**1,071		**731	
Gypsum[3]	65,554		72,655	
Limestone[4] and Dolomite	2,009		4,776	
Peat	**1,319		**1,491	
Salt	**60,312		**68,680	
Silica	**2,000		**2,600	
Total Non-Metals	134,458	882	153,081	867
(Structural Materials)				
Dimension Stone	374		303	
Cement	**45,000		**32,260	
Clay Products	**4,680		**5,000	
Plaster Products	**1,800		**0[2]	
Crushed Stone	33,939		43,575	
Sand & Gravel	17,751		14,032	
Total Structural Materials	103,544	797	95,170	700
Total Industrial Minerals	238,002	1,680	248,251	1,570
FUELS				
Coal	189,826	2,020	158,949	1,868
Petroleum - Crude	195,000	340	117,450	340
Total Fuels	384,826	2,360	276,399	2,208
TOTAL MINERAL PRODUCTION	623,000	4,000	524,650	3,800
CHANGE FROM PREVIOUS YEAR	5%	-7%	-16%	-5%

[1] Estimated from Department of Natural Resources sources

[2] There were no metal mines operating in 1996 or 1997

[3] Does not include the value of gypsum quarried for plaster products

[4] Does not include the value of limestone quarried for cement production

* Average number of persons during production period

** Processed or manufactured value

Note: Production represents shipments; numbers may not add to totals due to rounding

Table 1.3. Coal production for the calendar year 1997.

COMPANY	MINE NAME	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED[1]	APPROX. $VALUE[2]
			TONS	TONNES		
UNDERGROUND MINING						
Cape Breton Development Corp. (CBDC)	Prince Mine	Point Aconi, Cape Breton County				
	Phalen Mine	Lingan, Cape Breton County				
Total (underground)			2,638,906	2 394 000	1,743	
OPEN PIT MINING						
Black Gold Enterprises Limited	Springhill Rail Bed Project	Springhill, Cumberland County	12,501	11 341	8	
Brogan Mining Company Limited	Sullivan Creek and Toronto Rd. Mines	Sullivan Creek Cape Breton County	69,445	63 000	20	
Cape Crushing Company Limited	Merritt Point Mine	North Sydney, Cape Breton County	2,568	2 330	2	
Evans Coal Mines Limited	St. Rose Mine	St. Rose, Inverness County	58,977	53 504	29	
Pioneer Coal Limited	Stellarton Mine	Stellarton, Pictou County	181,565	164 715	46	
Thorburn Mining Limited	Thorburn Mine	Thorburn, Pictou County	22,177	20 119	20	
Total (open pit)			347,224	315 000	125	
TOTAL FOR ALL COAL PRODUCERS			**2,986,130**	**2 709 000**	**1,868**	**158,949,000**

[1] personnel employed in clerical, supervisory, etc. positions as well as mining personnel

[2] estimated from Nova Scotia Department of Natural Resources sources

NOTE: Production represents shipments; numbers may not add to totals due to rounding

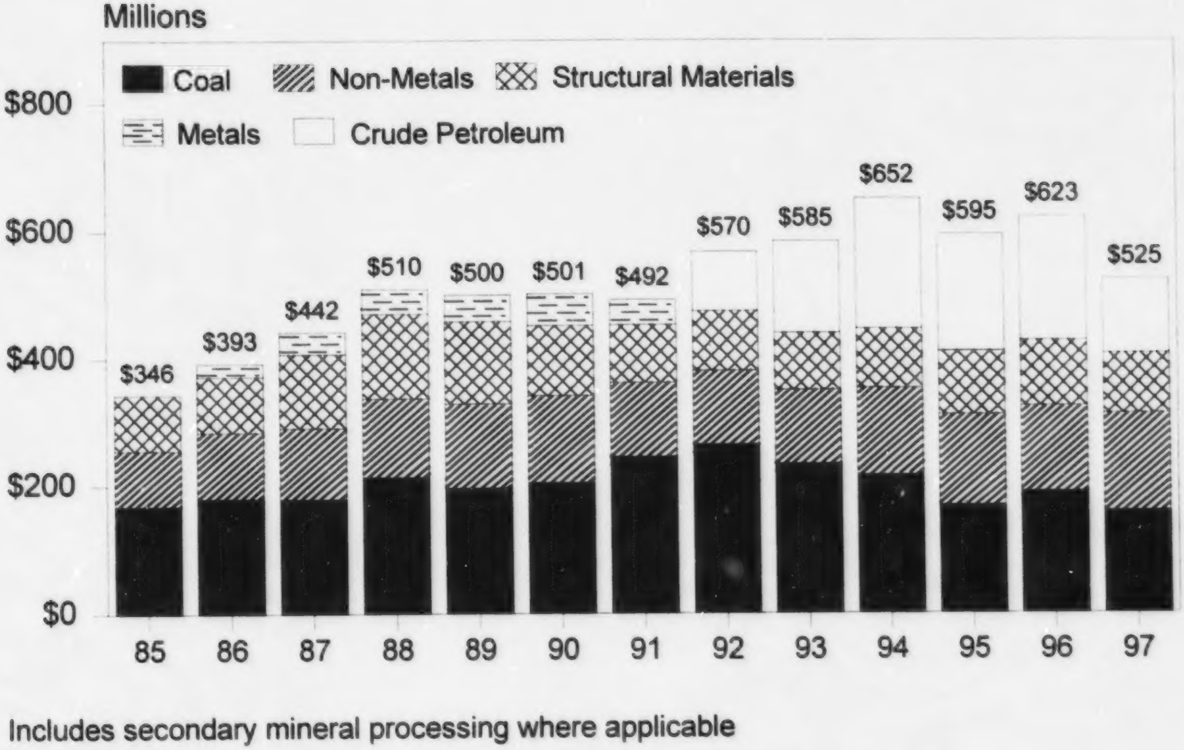


Figure 1.3. Historical trend of the value of mineral production in Nova Scotia, 1986-1997.

The Cape Breton Development Corporation is a federal Crown Corporation that operated two underground coal mines in Cape Breton County during 1996.

Phalen Colliery

Raw Coal
Production: 1,488,105 tons (1 350 000 tonnes)

The Phalen Colliery, near New Waterford, Cape Breton County, commenced production in 1987 in the Phalen Seam. The coal is extracted by the mechanical retreat longwall method. During the year, coal was mined from the No. 3 Center and No. 7 East longwall panels. Development work was conducted on the entries for the No. 8 East and No. 9 East panels.

Mining operations in No. 3 Center panel were interrupted by a roof fall in October 1997. Production at the mine resumed in January 1998.

Prince Mine

Raw Coal
Production: 1,074,606 tons (974 876 tonnes)

The Prince Mine is located in Point Aconi, Cape Breton County. The mine began underground production from the Hub Seam in 1975, initially using room and pillar methods. Mechanized retreat longwall operations began in 1980.

During 1997, coal was mined from the No. 15 West longwall panel. Development work was carried out on the No. 1 North longwall panel.

Table 1.4. Industrial minerals production for the calendar year 1997.

COMPANY	LOCATION	PRODUCTION TONS	PRODUCTION TONNES	TOTAL NUMBER EMPLOYED[1]	APPROXIMATE $VALUE[2]
GYPSUM					
Fundy Gypsum Co.	Miller Creek and Wentworth Road, Hants County	1,873,659	1 699 777	170	
Georgia-Pacific Corp.	Sugar Camp, Inverness County	1,088,026	987 051	88	
Little Narrows Gypsum Co.	Little Narrows, Victoria County	1,083,906	983 313	104	
National Gypsum (Canada) Limited	East Milford, Halifax County	3,767,844	3 418 166	100	
Total (gypsum)		7,813,000	7 088 300	462	72,655,200
ANHYDRITE					
Fundy Gypsum Co.	Miller Creek and Wentworth Road, Hants County	91,966	83 431	see gypsum	
Little Narrows Gypsum Co.	Little Narrows, Victoria County	106,590	96 698	see gypsum	
Total (anhydrite)		198,524	180 100		2,148,000
SALT					
The Canadian Salt Co. Ltd.	Pugwash, Cumberland County	1,288,297	1 168 735	210	
Sifto Canada Inc.	Nappan, Cumberland County	98,202	89 088	73	
Total (salt)		1,386,495	1 257 820	283	68,680,000[3]
LIMESTONE AND DOLOMITE					
Kelly Rock Ltd.	Glen Morrison, Cape Breton County	122,224	110 881	17	
Lafarge Canada Inc.	Brookfield, Colchester County	451,850	409 916	11	
Mosher Limestone Co. Ltd.	Upper Musquodoboit, Halifax County	77,492	70 300	22	
Ridge Brokers Ltd.	Southside Harbour, Antigonish County	8,501	7 712	1	
Scotia Limestone Ltd.	Kellys Cove, Victoria County	62,831	57 000	12	
Total (limestone and dolomite)		722,898	655 809	63	4,776,000[4]
BARITE					
E-Z-EM Canada Inc.	Brookfield, Colchester County	642	582	19	731,353[3]
Total (barite)		642	582	19	731,353[3]
CLAY					
Shaw Brick (a member of the Shaw Group Limited)	Lantz, Hants County Shubenacadie, Halifax County	17,414	15 798	2	0[5]
SHALE					
Shaw Brick (a member of the Shaw Group Limited)	Milford, Hants County New Glasgow, Pictou County	7,464	6 771	2	0[5]
Total (clay and shale)		24,878	22 569	4	0[5]

Table 1.4. Continued.

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED[1]	APPROXIMATE $VALUE[2]
		TONS	TONNES		
SILICA SAND					
Shaw Resources (a member of the Shaw Group Limited)	Nine Mile River, Hants County	64,704	58 699	6	2,600,000[3]
Total (silica sand)		64,704	58 699	6	2,600,000[3]
DIMENSION STONE					
Heritage Memorials Ltd.[2]	Quarry: Nictaux, Annapolis County (granite) Plant: Windsor, Hants County	1,929	1 750	20	
Wallace Quarries Ltd.	Quarry: Wallace, (Sandstone) Cumberland County	332	301	5	
Total (dimension stone)		2,261	2 051	25	303,000
PEAT MOSS					
Annapolis Valley Peat Moss Company	Berwick, Kings County	5,401	4 900	19	
Clare Organic Products Ltd.[2]	Meteghan Station, Digby County	2,250	2 041	15	
Total (peat moss)		7,651	6 941	34	1,491,000[3]
AGGREGATES					
Crushed Stone	Various	9,606,545	8 715 000	344	43,575,000
Sand and Gravel	Various	3,866,868	3 508 000	204	14,632,000
Total (aggregates)		13,473,413	12 223 000	548	57,607,000
TOTAL FOR INDUSTRIAL MINERALS[6]		23,695,000	21 496 000	1,444	210,992,000

[1] total employees: mining, production, clerical, supervisory, etc.

[2] estimate from Nova Scotia Department of Natural Resources sources

[3] processed or manufactured value

[4] does not include the value of Lafarge Canada Inc. production which value is transferred to the higher manufacturered value (cement)

[5] value assigned to the higher manufactured valuation (bricks)

[6] excluding secondary mineral manufacturing (Table 1.7)

Note: production represents shipments; numbers may not add to totals due to rounding

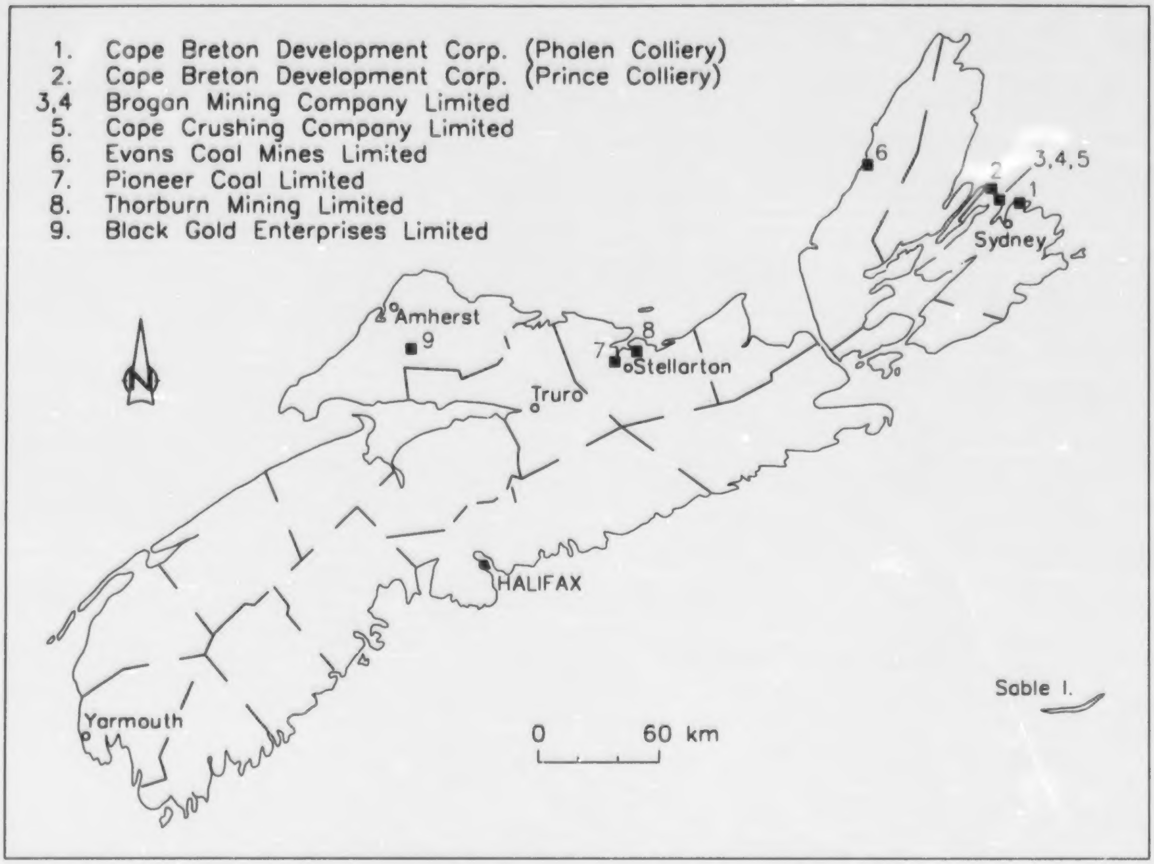

1. Cape Breton Development Corp. (Phalen Colliery)
2. Cape Breton Development Corp. (Prince Colliery)
3,4 Brogan Mining Company Limited
5. Cape Crushing Company Limited
6. Evans Coal Mines Limited
7. Pioneer Coal Limited
8. Thorburn Mining Limited
9. Black Gold Enterprises Limited
N
6
2
3,4,5
1
Sydney
Amherst
9
8
7
Stellarton
Truro
HALIFAX
Yarmouth
Sable I.
0
60 km

Figure 1.4. Locations of coal mines in Nova Scotia.

Surface Coal Mines

EVANS COAL MINES LIMITED

Manager: E. Fraser
Address: R. R. #1
Inverness, N. S. B0E 1N0
Production: 58,977 tons (53 504 tonnes) of coal
Employees: 29

The Evans Coal Mines Limited began surface coal mining operations at St. Rose, Inverness County, in 1993, following the closure of the underground mine in 1992. Coal is extracted from the No. 5 Seam crown pillar and from the pillars left behind by the underground operation. In 1997, mining was conducted during the periods from January to June and September to December. Mining proceeded in a southerly direction. Overburden and waste rock were removed by blasting and ripping by bulldozers. Material is loaded and hauled using hydraulic excavators and dump trucks. Extensive underground workings were encountered during the coal extraction process. During the year, the Duggan Mountain Road was temporarily relocated to facilitate mining and reclamation.

PIONEER COAL LIMITED

Manager: C. Chisholm
Address: P. O. Box 929
Westville, N. S. B0K 2A0
Production: 181,565 tons (164 715 tonnes) of coal
Employees: 46

Pioneer Coal began mining coal from the Foord Seam at the Stellarton mine site in March 1996, using hydraulic excavators and dump trucks. The seam was mined in both an easterly and westerly direction from the existing pit. The Foord Seam is approximately 40 feet thick. Mining becomes more selective in the western end

Table 1.5. Secondary mineral manufacturing for the calendar year 1997.

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED[1]	APPROX. $VALUE[2]
		TONS	TONNES		
CLAY PRODUCTS					
Shaw Brick (a member of the Shaw Group Limited)	Lantz, Hants County	24,878	22 569	45	5,000,000
PORTLAND CEMENT					
Lafarge Canada Inc.	Brookfield, Colchester County	292,631	265 473	77	32,260,000
TOTAL FOR SECONDARY MINERAL MANUFACTURING				122	37,260,000

[1] total number of employees including office, clerical, supervisory, mining and production
[2] estimated from Nova Scotia Department of Natural Resources sources
NOTE: Production represents shipments; numbers may not add to totals due to rounding

of the mine as the percentage of ash increases. The company conducted mining operations at the site from March to June and September to December.

The coal mined from the Stellarton operation was blended on-site with coal trucked from the Evans Coal Mine and the Thorburn Mine before being shipped to the Trenton generating station.

THORBURN MINING LIMITED

Manager:	C. Chisholm
Address:	P. O. Box 929 Westville, N. S. B0K 2A0
Production:	22,177 tons (20 119 tonnes) of coal
Employees:	20

Mining at the Thorburn site began in June 1995. In 1997, the mine operated from September to December.

Coal was extracted from the McBean Seam crown pillar and from pillars remaining from the former underground mining operations. During the year, overburden and waste rock were removed by ripping with bulldozers. Material was loaded and hauled using hydraulic excavators and dump trucks. The seam varies in thickness from 4 to 7 feet.

CAPE CRUSHING COMPANY LIMITED

Manager:	E. Brogan
Address:	P. O. Box 265 North Sydney, N. S. B2A 3M3
Production:	2,568 tons (2 330 tonnes) of coal
Employees:	2

The company operates a small surface coal mine at Alder Point, Cape Breton County. Coal was mined during the year from the Upper and Lower Bonar Seams using small scale excavating equipment.

BROGAN MINING COMPANY LIMITED

Manager:	R. Brogan
Address:	126 Main Street North Sydney, N. S. B1V 2L6
Production:	69,445 tons (63 000 tonnes) of coal
Employees:	20

The company operated two surface coal mines in Cape Breton County during 1997. Coal from both operations was blended to produce a saleable product.

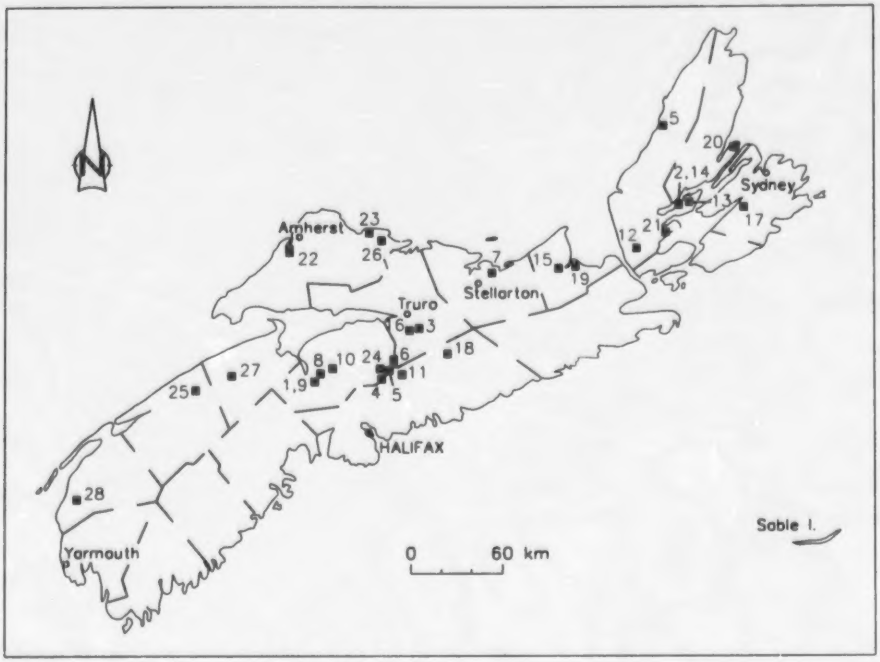
At Sullivans Creek, coal was mined from the Sydney Main Seam. Overburden was removed using a dragline, while waste rock and coal was mined with bulldozers, excavators and dump trucks. The company completed mining at the site during the year and began reclamation work.

At the Toronto Road mine site, surface mining operations recovered coal from both the Sydney Main and Stubbert coal seams. The coal was blended with coal mined from Sullivans Creek. Mining is carried out using bulldozers, hydraulic excavators and dump trucks. The company conducted progressive reclamation of the mined areas during the year.

BLACK GOLD ENTERPRISES LIMITED

Manager:	R. Smith
Address:	P. O. Box 576 Springhill, N. S. B0M 1X0
Production:	12,501 tons (11 341 tonnes) of coal
Employees:	8

The company commenced operations at the site in 1995 to recover coal from an abandoned rail bed in the Springhill area. The coal material is processed in a small portable wash plant installed on site. Operations during the year began in May and continued until November.


N
Amherst
22
23
26
Truro
6
3
Stellarton
7
15
19
18
8
10
24
6
1,9
11
4
5
27
25
HALIFAX
28
Yarmouth
5
20
2,14
Sydney
13
17
12
21
Sable I.
0
60 km

ANHYDRITE

1.	Fundy Gypsum Co.
2.	Little Narrows Gypsum Co.

BARITE

3.	E-Z-EM Canada Inc.

CLAY AND SHALE

4-7.	Shaw Brick, a member of the Shaw Group Limited

GYPSUM

8-9.	Fundy Gypsum Co.
10.	Domtar Gypsum
11.	National Gypsum (Canada) Ltd.
12.	Georgia-Pacific Corp.
13-14.	Little Narrows Gypsum Co. Ltd.
15.	Nova Construction Co. Ltd.

LIMESTONE AND DOLOMITE

16.	Lafarge Canada Inc.
17.	Kelly Rock Limited
18.	Mosher Limestone Co. Ltd.
19.	Ridge Brokers Ltd.
20.	Scotia Limestone Ltd.
21.	Shaw Resources, a member of the Shaw Group Limited

SALT

22.	Sifto Canada Inc.
23.	The Canadian Salt Co. Ltd.

SILICA SAND

24.	Shaw Resources, a member of the Shaw Group Limited

DIMENSION STONE

25.	Heritage Memorials Ltd.
26.	Wallace Quarries Ltd.

PEAT MOSS

27.	Annapolis Valley Peat Moss Co.
28.	Clare Organic Products Limited

Figure 1.5. Location of industrial mineral operations in Nova Scotia.

Industrial Minerals Mining

Gypsum and Anhydrite

GEORGIA-PACIFIC CANADA INCORPORATED

Manager: D. Duncan
Address: P. O. Box 400
Port Hawksbury, N. S. B0E 2V0
Production: 0 tons (0 tonnes) of gypsum
Employees: 0

There was no production at the mine in 1997.

FUNDY GYPSUM COMPANY LIMITED

Manager: T. Davis
Address: P. O. Box 400
Windsor, N. S. B0N 2T0
Production: 91,966 tons (83 431 tonnes) of anhydrite
1,873,659 tons (1 699 772 tonnes) of gypsum
Employees: 170

The Fundy Gypsum Company operates quarries and crushing plants in the Wentworth Creek and Miller Creek areas near Windsor, Hants County. In 1997, the company produced gypsum from its Miller Creek quarry and both gypsum and anhydrite from the Wentworth Creek quarry. The Wentworth Creek ore is processed in the company's heavy media plant to separate anhydrite from gypsum.

The gypsum and anhydrite are transported by unit train to ship-loading facilities at Hantsport, a distance of 12 miles (19 km). These products are transported to wallboard and cement plants in the United States.

GEORGIA-PACIFIC CORPORATION

Manager: J. Graham
Address: P. O. Box 400
Port Hawksbury, N. S. B0E 2V0
Production: 1,088,026 tons (987 051 tonnes) of gypsum
Employees: 88

Georgia-Pacific Corporation operates a gypsum quarry at Sugar Camp, Inverness County. Overburden at the site is removed using a dragline and truck and shovels. The gypsum is drilled and blasted prior to being transported to the crusher by trucks. The crushed gypsum is then transported by truck to ship loading facilities at Point Tupper, Richmond County, a distance of 12 miles (19 km).

LITTLE NARROWS GYPSUM COMPANY LIMITED

Manager: Bruce Allan
Address: R. R. #1
Little Narrows, N. S. B0E 1T0
Production: 106,590 tons (96 698 tonnes) of anhydrite
1,083,906 tons (983 313 tonnes) of gypsum
Employees: 104

Little Narrows Gypsum Company Limited operates two gypsum quarries and one anhydrite quarry near Little Narrows, Victoria County. All the gypsum and anhydrite produced is shipped from the company's dock on the Bras d'Or Lakes to destinations in Canada and the United States.

NATIONAL GYPSUM (CANADA) LIMITED

Manager: Pat Mills
Address: P. O. Box 57
Milford, N. S. B0N 1Y0
Production: 3,767,844 tons (3 418 166 tonnes)
Employees: 100

National Gypsum (Canada) Limited operates the largest gypsum quarry in the province at East Milford, Halifax County. The gypsum is drilled and blasted and loaded onto trucks with hydraulic excavators and loaders. The gypsum is then transported by unit train from Milford to Wright's Cove, Dartmouth, a distance of 28 miles (45 km), where it is loaded onto ships for points in Canada and the United States.

NOVA CONSTRUCTION COMPANY LIMITED

President: J. Chisholm
Address: P. O. Box 1328
Antigonish, N. S. B2G 2L7
Production: 0 tons (0 tonnes) of gypsum
Employees: 12 (when in production)

There was no production from this quarry at Brierly Brook, Antigonish County, in 1997.

Salt

THE CANADIAN SALT COMPANY LIMITED

Manager: A. Davidson
Address: P. O. Box 160
Pugwash, N. S. B0K 1L0
Production: 1,288,297 tons (1 168 735 tonnes) of salt
Employees: 210

The Canadian Salt Company Limited mine is located at Pugwash, Cumberland County. The salt is mined by a room and pillar system of extraction, using diesel and electric drills, undercutters, loaders and trucks. Primary production during the year was from the 1000 foot level. Secondary production was from the 730 foot level and the 830 foot level.

The processing plant at the site produces industrial grades of salt, salt blocks for farm use and refined salt for domestic consumption. Transportation is either by road, rail or from the company owned ship-loading facility at Pugwash.

SIFTO CANADA INCORPORATED

Manager: D. Dickie
Address: P. O. Box 550
Amherst, N. S. B4H 4A1
Production: 98,202 tons (89 088 tonnes) of salt
Employees: 73

Salt has been produced from a solution salt mine at Nappan, Cumberland County, since 1947. Salt is mined by pumping water into underground wells where the salt is dissolved by the water and the resulting brine solution is then pumped back to the surface. The salt is then recovered from the brine in a processing plant, using a 'mechanical vapour recompression evaporating process' system.

During the year, salt was produced from the No. 7 and No. 8 brine wells.

Barite

E-Z-EM CANADA INCORPORATED, NYSTONE DIVISION

Manager: V. Prostak
Address: P. O. Box 69
Debert, N. S. B0M 1G0
Production: 642 tons (582 tonnes) of pharmaceutical grade barite
Employees: 19

The barite deposit is located 1 mile (1.6 km) northeast of Brookfield, Colchester County. During 1997, the surface mine was dewatered and approximately 1,650 tons (1 497 tonnes) of ore were mined from the pit. All of the material that had previously been mined and stockpiled at the mine was trucked to the company's plant at Debert where it was upgraded to a pharmaceutical quality product. Refined products are then transported to the parent company, E-Z-EM Corporation, New York, USA, for further processing and packaging.

Limestone and Dolomite

LAFARGE CANADA INC.

Manager: J. Cross
Address: P. O. Box 5
Brookfield, N. S. B0N 1C0
Production: 451,850 tons (409 916 tonnes) of limestone
Employees: 11 (quarry) 77 (cement plant)

Lafarge Canada Inc. operates a limestone quarry at their Brookfield cement manufacturing plant, located 3 miles (5 km) west of Brookfield. The total production from the quarry is used to produce cement.

MOSHER LIMESTONE COMPANY LIMITED

Manager: D. Mosher
Address: P. O. Box 28
Upper Musquodoboit, N. S.
B0N 2M0
Production: 77,492 tons (70 300 tonnes) of limestone
Employees: 22

Mosher Limestone operates quarries near Upper Musquodoboit, Halifax County. The company produces agricultural grade dolomitic limestone in its grinding plant at Upper Musquodoboit. The product is bagged or supplied in bulk for distribution throughout the Atlantic Provinces. In 1996, the company began producing a pelletized limestone product for the domestic garden market.

SHAW RESOURCES, A MEMBER OF THE SHAW GROUP LIMITED

Manager: K. Hardie
Address: P. O. Box 60
Shubenacadie, N. S. B0N 2H0
Production: 0 tons (0 tonnes) of marble
Employees: 2 (when in production)

Shaw Resources produces marble intermittently from a quarry at Marble Mountain, Inverness County. This marble is used for brick manufacture and in landscaping.

RIDGE BROKERS LIMITED

Manager: A. Alward
Address: P. O. Box 59
Havelock, N. B. E0A 1W0
Production: 8,501 tons (7 712 tonnes) of limestone
Employees: 1

The company operates a small quarry at Southside, Antigonish Harbour, Antigonish County. During the year, 16,535 tons (15 000 tonnes) of limestone was drilled, blasted, screened and crushed at the site.

SCOTIA LIMESTONE LIMITED

Manager: D. Mosher
Address: P. O. Box 28
Upper Musquodoboit, N. S. B0N 2M0
Production: 68,831 tons (57 000 tonnes) of dolomite
Employees: 12

In 1996, Mosher Limestone Company Limited purchased the assets of the Kellys Cove dolomite quarry from Scotia Limestone. The mine produced an agricultural grade dolomite for domestic sale as well as a product for the offshore steel industry. No mining took place at the site during 1997; all production came from existing inventory.

KELLY ROCK LIMITED

Manager: D. MacKenna
Address: P. O. Box 1206
Sydney, N. S. B1P 6J9
Production: 122,224 tons (110 881 tonnes) of limestone
Employees: 17

The limestone quarry at Glen Morrison, Cape Breton County, began production in 1993. The company produces several products at the on-site milling facility. In 1996, the company completed construction of a secondary and tertiary processing plant and a large limestone storage facility. During the year, most of the production from this site was shipped to Point Aconi for use in the fluidized bed power generating station.

Clay

SHAW BRICK, A MEMBER OF THE SHAW GROUP LIMITED

Manager: B. Frizzell
Address: P. O. Box 2130
Lantz, N. S. B0N 1R0
Production: 24,569 tons (22 569 tonnes) of clay & shale
Employees: 4

Shaw Brick mines clay from pits at Lantz, Milford and Shubenacadie, all in Hants County, and shale from a quarry in New Glasgow, Pictou County. These materials are used in the company's plant in Lantz for the manufacture of bricks and other structural clay products.

Silica Sand

SHAW RESOURCES, A MEMBER OF THE SHAW GROUP LIMITED

Manager: K. Hardie
Address: P. O. Box 60
Shubenacadie, N. S. B0N 2H0
Production: 64,704 tons (58 699 tonnes) of silica sand
Employees: 6

Shaw Resources produces silica sand from a deposit at West Indian Road, Hants County. This sand is processed into several silica sand products including glass grade sand.

Dimension Stone

HERITAGE MEMORIALS LIMITED

Manager: G. Nelson
Address: P. O. Box 308
Windsor, N. S. B0N 2T0
Production: 1,929 tons (1 750 tonnes) of granite (est.)
Employees: 20

The company periodically operates a small quarry at Nictaux West, Annapolis County. The grey granite is used as dimension stone at the company's memorial manufacturing plant at Windsor, Hants County.

WALLACE QUARRIES LIMITED

Manager: S. Flynn
Address: P. O. Box 203
Wallace, N. S. B0K 1Y0
Production: 332 tons (301 tonnes) of building stone
Employees: 5

The Wallace Quarries, located near Wallace, Cumberland County, continued to supply building stone for major building rehabilitation work in Halifax and central Canada. Blocks of stone are sent for cutting to processing facilities in Nova Scotia, New Brunswick and Quebec to supply local markets.

Peat Moss

ANNAPOLIS VALLEY PEAT MOSS COMPANY LIMITED

President:	H. Endres
Address:	Berwick, N. S. B0P 1E0
Production:	5,401 tons (4 900 tonnes) of peat moss
Employees:	19 (some part time)

The company uses vacuum harvesters to recover agricultural peat from a 500 acre (200 ha) bog located near Berwick, Kings County. Baled peat products are shipped to markets in Canada, the United States and Japan.

CLARE ORGANIC PRODUCTS LIMITED

Owner:	Gerald Thimot
Address	Box 174-A, Saulnierville Digby County, N. S. B0W 2Z0
Production:	2,250 tons (2 041 tonnes)
Employees:	15 (some part time)

1996 was the first year of production for the company, which uses vacuum harvesters to recover agricultural peat from a 200 acre (81 ha) bog located near Meteghan Station, Digby County. The company has a contract to supply a major Maritime peat producer with baled peat destined for international markets.

Aggregate Resources

Approximately 12 million tonnes of construction aggregates were produced in Nova Scotia in 1997. Twenty-five companies reported crushed stone production totalling 8.7 million tonnes while 42 producers reported sand and gravel production totalling 3.5 million tonnes. The majority of aggregate was consumed within the province, with approximately 1.7 million tonnes exported.

Two companies eclipsed the 1 million tonne mark for crushed stone production in 1997. Rocky Lake Quarry Limited of Bedford, Nova Scotia, reported shipments of 1.3 million tonnes while Martin Marietta Materials Canada Ltd. reported just over 1.8 million tonnes shipped. Martin Marietta's Porcupine Mountain operation was the country's eight largest in 1997.

Appendix 2

Minerals and Energy Branch Geoscience Maps and Publications for Sale

BEDROCK GEOLOGY MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00**

1:640 000

Outside Publication ME 1989-1 Geological Highway Map of Nova Scotia, Second Edition, by Howard V. Donohoe, Jr., and R. G. Grantham, scale 1:640 000, 1989 (Atlantic Geoscience Society, Special Publication Number 1). **$3.50**

1:500 000

Map ME 1979-1 Geological Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1979, with Metamorphic and Structural Map Inserts, by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50**

Regional Scale

1:250 000

Map ME 1994-1 Geological Map of the South Mountain Batholith, Western Nova Scotia, compiled by M. A. MacDonald with contributions from M. C. Corey, L. J. Ham and R. J. Horne, 1994, scale 1:250 000. **$6.00**

1:125 000

Map ME 1983-4 Geological Map of the Red River Anorthosite Complex, Inverness and Victoria Counties, Nova Scotia, by P. K. Smith and A. S. Macdonald, scale 1:125 000. **$1.50**

Map ME 1978-1 Preliminary Geology Map of the Cobequid Highlands, by H. V. Donohoe and P. I. Wallace, scale 1:125 000, (Superseded by Map ME 1982-6, Map ME 1982-7, Map ME 1982-8, Map ME 1982-9, scale 1:50 000). **$3.50**

1:100 000

OFM ME 1998-1 Preliminary Geological Map of Guysborough, Richmond and Antigonish Counties (parts of NTS sheets 11E/08, 11F/05, 11F/06, 11F/10, 11F/11, 11F/12 and 11F/15, Nova Scotia, Canada, by C. E. White and S. M. Barr, 1998, 1 coloured map, scale 1:100 000. **$5.00**

Map ME 1984-2 Geological Map of the Boisdale Peninsula, Central Cape Breton Island, Cape Breton County, Nova Scotia, by Sandra M. Barr and Jeremy R. D. Setter, 1984, scale 1:100 000. **$4.00**

Detailed Scale

1:50 000

Map ME 1996-1 Geological Map of the Shubenacadie and Musquodoboit Basins Showing the Extent of Early Cretaceous Sediments (part of NTS Map Sheet 11E/03), Colchester and Halifax Counties, Nova Scotia, by R. R. Stea, P. W. Finck, S. E. Pullan, and M. C. Corey, 1996, scale 1:50 000. **$6.00**

Map ME 1994-8 Geological Map of Bridgetown, Nova Scotia (NTS Sheet 21A/14): South Mountain Batholith Project, by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-7 Geological Map of Digby, Nova Scotia (NTS Sheet 21A/12): South Mountain Batholith Project, by L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-6 Geological Map of Milford, Nova Scotia (NTS Sheet 21A/11): South Mountain Batholith Project, by M. C. Corey and R. J. Horne, 1994, scale 1:50 000. **$6.00**

Map ME 1994-5 Geological Map of Kejimkujik Lake, Nova Scotia (NTS Sheet 21A/06 and part of 21A/07): South Mountain Batholith Project, by R. J. Horne and M. C. Corey, 1994, scale 1:50 000. **$6.00**

Map ME 1994-4 Geological Map of Weymouth, Nova Scotia (NTS Sheet 21A/05): South Mountain Batholith Project, by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-3 Geological Map of Wentworth Lake (NTS Sheet 21A/04 and part of 20P/13): South Mountain Batholith Project, by L. J. Ham and M. A. MacDonald, 1994, scale 1:50 000. **$6.00**

Map ME 1994-2 Geological Map of Lake Rossignol, Nova Scotia (NTS Sheet 21A/03 West Half): South Mountain Batholith Project, by M. C. Corey and R. J. Horne, 1994, scale 1:50 000. **$6.00**

Map ME 1993-1 Geological Map of New Germany (NTS Sheet 21A/10), Nova Scotia, by R. J. Horne, 1992, scale 1:50 000. **$6.00**

Map ME 1992-1 Geological Map of Gaspereau Lake (NTS Sheet 21A/15 and part of 21H/02), Nova Scotia, by M. A. MacDonald and L. J. Ham, 1992, scale 1:50 000. **$6.00**

Map ME 1990-14 Cumberland Basin Geology Map, Tatamagouche and Malagash, Cumberland, Colchester and Pictou Counties, by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000. **$6.00**

Map ME 1990-13 Cumberland Basin Geology Map, Oxford and Pugwash, Cumberland County, by R. J. Ryan, R. C. Boehner and A. Deal, 1990, scale 1:50 000. **$6.00**

Map ME 1990-12 Cumberland Basin Geology Map, Amherst, Springhill and Parrsboro, Cumberland County, by R. J. Ryan, R. C. Boehner, A. Deal and J. H. Calder, 1990, scale 1:50 000. **$6.00**

Map ME 1990-11 Cumberland Basin Geology Map, Apple River and Cape Chignecto, Cumberland County, by R. J. Ryan, R. C. Boehner and A. Deal, 1990, scale 1:50 000. **$6.00**

Map ME 1990-10 Geological Map of Windsor (21A/16, West Half and part of 21H/01), Nova Scotia, by L. J. Ham, scale 1:50 000. **$6.00**

Map ME 1990-9 Geological Map of Chester (21A/09), Nova Scotia, by M. C. Corey, scale 1:50 000. **$7.00**

Map ME 1989-4 Geology of Mabou Highlands (NTS sheet 11K/03, west half), Nova Scotia, by S. M. Barr and A. S. Macdonald, 1989, colour map, scale 1:50 000 (accompanies Paper ME 1989-2). **$3.00**

Map ME 1987-8 Bedrock Geological Map of Mount Uniacke (11D/13 West), by M. C. Corey, 1987, scale 1:50 000. **$6.00**

Map ME 1987-7 Bedrock Geological Map of Windsor (21A/16 East), by L. J. Ham and R. J. Horne, 1987, scale 1:50 000. **$6.00**

Map ME 1987-6 Bedrock Geological Map of Halifax and Sambro (11D/12 and 11D/05), by M. A. MacDonald and R. J. Horne, 1987, scale 1:50 000. **$6.00**

Map ME 1986-1 Geological Map of the Sydney Basin, Cape Breton Island, Nova Scotia, by R. C. Boehner and P. S. Giles, 1986, scale 1:50 000. **$5.00**

Map ME 1985-2 Geological Map of the Loch Lomond Basin and Glengarry Half Graben, by R. C. Boehner and G. Prime, scale 1:50 000. **$5.00**

Map ME 1982-9 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Debert - Mt. Thom Region, Sheet 4 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each; $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-8 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Economy River - Folly Lake Region, Sheet 3 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each; $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-7 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Parrsboro - Five Islands Region, Sheet 2 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each; $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-6 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Advocate Harbour - Port Granville Region, Sheet 1 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each; $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-5 Geological Map of the Northern Antigonish Highlands, Nova Scotia, by J. B. Murphy, J. D. Keppie and A. Hynes, scale 1:50 000. **$4.00**

Map ME 1982-4 Geological Map of the Shubenacadie and Musquodoboit Basins, by P. S. Giles and R. C. Boehner, scale 1:50 000. **$5.00**

Map ME 1982-3 Geological Map of the Eureka Area, by P. S. Giles, scale 1:50 000. **$3.00**

Map ME 1982-2 Geological Map of the Antigonish Basin, by R. C. Boehner and P. S. Giles, scale 1:50 000. **$3.00**

1:31 680

!!!NEW!!!

Map ME 1967-3 Geology, Area of Christopher McLeod Brook, Victoria County, Nova Scotia, by G. C. Milligan, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

!!!NEW!!!

Map ME 1967-2 Geology, Middle River Area, Inverness and Victoria Counties, Nova Scotia, by G. C. Milligan, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

!!!NEW!!!

Map ME 1967-1 Geology, Crowdis Mountain Area, Victoria County, Nova Scotia, by G. C. Milligan, R. C. Parsons, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

!!!NEW!!!

Map ME 1963-2 Geology, Boisdale Hills, Scotch Lake to Steeles Crossing, Cape Breton County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1963, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

!!!NEW!!!

Map ME 1963-1 Geological Map of the Craignish Hills, Inverness County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1963, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

!!!NEW!!!

Map ME 1962-1 Geology, North Mountain, Inverness County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1962, black/white map, scale 1:31 680 (accompanies Memoir ME 7). **$1.00**

1:25 000

Map ME 1997-1 Geological Map of a Portion of the South-Central Cape Breton Highlands (part of NTS map sheet 11K/07), Victoria and Inverness Counties, Nova Scotia, by L. J. Ham, 1997, scale 1:25 000. Accompanies Paper ME 1997-1. **$6.00**

Map ME 1995-2, Second Edition Geological Map of a Portion of the South-Central Cape Breton Highlands (parts of NTS Map Sheets 11K/07 and 11K/10), Victoria and Inverness Counties, Nova Scotia, by R. J. Horne, revised September 1996, scale 1:25 000. **$6.00**

OFM ME 1994-6 Bedrock Geology Map of the Southeast Cape Breton Highlands, Nova Scotia (part of NTS Sheet 11K/07), Inverness and Victoria Counties, by L. J. Ham, 1994, scale 1:25 000. **$2.00**

OFM ME 1994-2 Location Map of Bedrock Samples, South-Central Cape Breton Highlands (NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia, by R. J. Horne and L. J. Ham, 1994, scale 1:25 000 (2 sheets). **$4.00**

OFM ME 1994-1 Bedrock Geology Map of the South-Central Cape Breton Highlands, Nova Scotia (parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, by R. J. Horne, 1994, scale 1:25 000. **$2.00**

OFM ME 1991-1 Preliminary Geological Map of West-Central Cape Breton Highlands (11K/07 and 11K/10), by R. J. Horne, 1991, scale 1:25 000. **$2.00**

Map ME 1986-2 Geological Map of the Windsor Area, Nova Scotia, by Reginald G. Moore and Stewart A. Ferguson, 1986, scale 1:25 000. **$5.00**

Map ME 1983-1 Geological Map of the Hantsport Area, Nova Scotia, compilation and geology by S. A. Ferguson, scale 1:25 000. **$5.00**

1:20 000

!!!NEW!!! **OFM ME 1998-14** Geological Map of the McAdams Lake area, Cape Breton County (parts of NTS sheets 11F/15, 11F/16, 11K/01 and 11K/02) Nova Scotia, by C. E. White and S. M. Barr, 1998, 1 colour map, scale 1:20 000. **$5.00**

1:10 000

OFM ME 1998-13 Geological Map of Renfrew (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-12 Geological Map of Bill Meadow Mountain (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-11 Geological Map of Woodville (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, Nova Scotia Department of Natural Resources, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-10 Geological Map of Newport Corner (part of NTS sheet 11D/13), Hants County, Nova Scotia, by R. J. Horne, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-9 Geological Map of Waverley (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, D. E. Baker and L. J. Ham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-8 Geological Map of Middle Sackville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, L. A. MacDonald and D. E. Baker, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-7 Geological Map of Lucasville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and L. A. MacDonald, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-6 Geological Map of Fall River (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and D. E. Baker, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-5 Geological Map of Soldier Lake (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by M. Feetham, R. J. Horne, D. E. Baker and L. J. Ham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-4 Geological Map of Halifax Airport (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by D. E. Baker, R. J. Horne and M. Feetham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1997-6 Geological Map of Gore (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-5 Geological Map of Greenfield (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-4 Geological Map of Greenhill (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-3 Geological Map of East Gore (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-2 Geological Map of Upper Rawdon (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-1 Geological Map of Upper Nile Mile River (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

Map ME 1995-1 Geological Map of the Springhill Coalfield, Cumberland County, Nova Scotia, by J. H. Calder, 1995, scale 1:10 000. **$6.00**

OFM ME 1994-5 Preliminary Geological Map, Rawdon Area, Hants County, Nova Scotia (NTS Sheet 11E/04), by R. J. Horne, 1994, scale 1:10 000. **$2.00**

OFM ME 1993-2 Geological Map of the Cogmagun River - Goshen Quadrangle (NTS 21H/01), Nova Scotia, by R. G. Moore, 1993, scale 1:10 000. **$2.00**

OFM ME 1993-1 Geological Map of the Cheverie - Lower Burlington Quadrangle (NTS 21H/01), Nova Scotia, by R. G. Moore, 1993, scale 1:10 000. **$2.00**

OFM ME 1992-6 Geological Map of the Debert - Kemptown Coalfield (parts of NTS 11E/05, 06, 07, 11, 12), by R. Naylor, 1992, scale 1:10 000 (6 sheets). **$12.00 set**

OFM ME 1989-1 Geological Map of the Kentville-South Alton Quadrangle, compiled by Stewart A. Ferguson, 1989, scale 1:10 000. **$2.00**

OFM ME 1989-3 Geological Map of the Newport Corner Quadrangle, by R. G. Moore, 1988, scale 1:10 000. **$2.00**

OFM ME 1989-2 Geological Map of the West Gore Quadrangle, by R. G. Moore, 1988, scale 1:10 000. **$2.00**

OFM ME 1988-43 Preliminary Geological Maps of the Cumberland Basin, Amherst (21H/16), by R. C. Boehner, R. J. Ryan and A. Deal, 11 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-42 Preliminary Geological Maps of the Cumberland Basin, Springhill and Apple River (21H/09 and 21H/10), by R. J. Ryan, A. Deal, J. H. Calder and R. C. Boehner, 24 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-41 Preliminary Geological Maps of the Cumberland Basin, Cape Chignecto and Parrsboro (21H/07 and 21H/08), by A. Deal, R. J. Ryan and R. C. Boehner, 13 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-40 Preliminary Geological Maps of the Cumberland Basin, Pugwash and Malagash (11E/13 and 11E/14), by R. J. Ryan, R. C. Boehner and A. Deal, 21 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-39 Preliminary Geological Maps of the Cumberland Basin, Tatamagouche and Oxford (11E/11 and 11E/12), by R. J. Ryan, R. C. Boehner and A. Deal, 23 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-24 Geological Map of New Minas - Canaan Quadrangle, compiled by Dr. Stewart A. Ferguson 1988, scale 1:10 000. **$2.00**

1:6000

OFM ME 1990-2 Map of the Glencoe Limestone Deposit, Inverness County (11F/14), 1988 Diamond-Drilling; Diamond-Drill Holes and Sections, by R. H. MacDonald, scale 1:6000. **$2.00**

1:5000

OFM ME 1989-17 Geological Map of the Stellarton Basin (West Half), Pictou County, Nova Scotia, by W. D. Smith, K. S. Gillis, S. A. Montgomery, scale 1:5000. **$2.00**

1:1600

Map ME 1990-3 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 830 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-2 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 730 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-1 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 630 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

1:240

!!!NEW!!!

Map ME 1968-1 Silver Cliff Prospect, Dauphinee Brook, Inverness County, Nova Scotia, by G. C. Milligan and A. K. Chatterjee, 1968, black/white map, scale 1:240 (accompanies Memoir ME 7). **$1.00**

1:70

Map ME 1984-1 Geological Map of the Cochrane Hill Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:70. **$8.00**

GLACIAL/SURFICIAL GEOLOGY MAPS

Provincial Scale

1:500 000

Map ME 1992-3 Surficial Geology Map of the Province of Nova Scotia, compiled by R. R. Stea, H. Conley and Y. Brown, 1992, scale 1:500 000. **$5.00**

Regional Scale

1:250 000

Map ME 1992-2 Glacial Geology Map of the South Mountain Batholith (NTS Sheets 11D, 21A and 20P), Western Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1992, scale 1:250 000. **$5.00**

Map ME 1989-3 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 3 (Cape Breton Island), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-2 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 2 (Central Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-1 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 1 (Southwestern Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1985-6 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000 (locates and shows the type, quality and observed thickness of sand and gravel deposits). **$3.00**

Map ME 1985-3, Map ME 1985-4, Map ME 1985-5 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000, (locates and names aggregate pits and quarries). **$3.00 each; $10.00 set**

1:100 000

Map ME 1990-6 Surficial Geology Map of Parts of Halifax, Pictou, Antigonish and Guysborough Counties (Sheet 12), Map Sheets 11E/09, 10, 15, 16 and parts of 11E/07 and 11E/08, by R. R. Stea and R. A. Myers, 1990, scale 1:100 000. **$13.00**

OFM ME 1988-51 Till Geochemistry Map of Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:100 000. **$2.00**

OFM ME 1988-50 Till Geochemistry Map of Northern Mainland Nova Scotia, Clay Fraction Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:00 000. **$2.00**

OFM ME 1988-32 Till Geochemistry Map, Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

OFM ME 1988-31 Till Geochemistry Map, Pictou and Antigonish Counties (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

Map ME 1988-14 Surficial Geology Map of Parts of Colchester, Cumberland, Pictou and Hants Counties, Nova Scotia (Sheet 11), by R. R. Stea and P. W. Finck, 1988, scale 1:100 000. **$4.00**

Map ME 1988-13 Surficial Geology Map of Parts of Colchester, Cumberland, Pictou and Hants Counties, Nova Scotia (Sheet 10), by R. R. Stea and P. W. Finck, 1988, scale 1:100 000. **$4.00**

Map ME 1982-10 Pleistocene Geology and Till Geochemistry Map of Southwestern Nova Scotia (Sheets 7 and 8), by R. R. Stea and D. R. Grant, scale 1:100 000, (Sheet 9 is Map 1630A in Geological Survey of Canada Paper 85-17). **$8.00**

Map ME 1982-1 Pleistocene Geology and Till Geochemistry Map of South-Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000, (Sheet 5 is in Open File Report ME 555). **$3.50**

Map ME 1981-1 Pleistocene Geology and Till Geochemistry Map, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 are in Paper ME 1979-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. **$3.50**

Detailed Scale

1:50 000

!!!NEW!!!

OFM ME 1998-3 Surficial Geology of the Shubenacadie area (NTS 11E/03), Colchester, Halifax and Hants Counties, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998, 1 coloured map, scale 1:50 000. **$5.00**

OFM ME 1998-2 Surficial Geology of the Bridgetown area (NTS 21A/14), Annapolis County, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998, 1 coloured map, scale 1:50 000. **$5.00**

Map ME 1994-14 Glacial and Till Clast Geology Map of Gaspereau Lake, Nova Scotia (NTS Sheet 21A/15): South Mountain Batholith Project, by P. W. Finck, R. M. Graves, F. J. Boner and H. B. Bent, 1994, scale 1:50 000. **$6.00**

Map ME 1994-13 Glacial and Till Clast Geology Map of Milford, Nova Scotia (NTS 21A/11): South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-12 Glacial and Till Clast Geology Map of Kejimkujik Lake, Nova Scotia (NTS Sheets 21A/06 plus part of 21A/07): South Mountain Batholith Project, by P. W. Finck, F. J. Boner and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-11 Glacial and Till Clast Geology Map of Weymouth, Nova Scotia (NTS Sheet 21A/05): South Mountain Batholith Project, by P. W. Finck, R. M. Graves and F. J. Boner, 1994, scale 1:50 000. **$6.00**

Map ME 1994-10 Glacial and Till Clast Geology Map of Wentworth Lake, Nova Scotia (NTS Sheet 21A/04 plus part of 20P/13): South Mountain Batholith Project, by P. W. Finck, F. J. Boner and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-9 Glacial and Till Clast Geology Map of Lake Rossignol, Nova Scotia (NTS Sheet 21A/03 West): South Mountain Batholith Project, by P. W. Finck, R. M. Graves and F. J. Boner, 1994, scale 1:50 000. **$6.00**

OFM ME 1993-13 Glacial and Till Clast Geology Map of Digby (NTS 21A/12), Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1993, scale 1:50 000. **$2.00**

Map ME 1993-2 Glacial and Till Clast Geology Map of New Germany (NTS Sheet 21A/10), Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1992, scale 1:50 000. **$6.00**

OFM ME 1991-5 to OFM ME 1991-18 Aggregate Potential of Cumberland and Colchester Counties, 14 Preliminary Map Sheets, scale 1:50 000 (11E/02, 11E/03, 11E/05, 11E/06, 11E/07, 11E/11, 11E/12, 11E/13, 11E/14, 21H/07, 21H/08, 21H/09, 21H/10, 21H/16), by G. Prime, 1991. **$2.00 per NTS Map Sheet**

Map ME 1990-4 Till Clast and Glacial Geology Map of Chester (21A/09), Nova Scotia, by R. M. Graves and P. W. Finck, 1990, scale 1:50 000. **$11.00**

OFM ME 1988-52 Preliminary Till Geochemistry and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, scale 1:50 000. **$2.00**

OFM ME 1988-14 Glacial and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by P. W. Finck, R. M. Graves, F. J. Boner and H. G. Bent, scale 1:50 000. **$2.00**

Map ME 1987-4 Till Clast and Simplified Glacial Geology Map of Halifax-Sambro (11D/12 and 11D/05), by R. M. Graves and P. W. Finck, 1987, scale 1:50 000. **$6.00**

Map ME 1987-3 Till Clast and Simplified Glacial Geology Map of Mount Uniacke (11D/13 West), by R. M. Graves and P. W. Finck, 1987, scale 1:50 000. **$6.00**

Map ME 1987-2 Glacial Geology Map of Halifax and Sambro (11D/12 and 11D/05), by P. W. Finck and R. M. Graves, 1987, scale 1:50 000. **$6.00**

Map ME 1987-1 Glacial Geology Map of Mount Uniacke (11D/13 West), by P. W. Finck and R. M. Graves, 1987, scale 1:50 000. **$6.00**

1:25 000

OFM ME 1992-2 Surficial Geology of the South-Central Cape Breton Highlands (11K/07), by P. W. Finck, 1992, scale 1:25 000. **$2.00**

GEOCHEMISTRY MAPS

Provincial Scale

1:1 500 000

OFM ME 1990-15 Geochemical Atlas of Nova Scotia: Part I, Drainage Surveys, compiled by P. A. Lombard, 119 maps, 4 overlays. **$50.00**

Regional Scale

1:100 000

OFM ME 1988-51 Till Geochemistry Map of Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:100 000. **$2.00**

OFM ME 1988-50 Till Geochemistry Map of Northern Mainland Nova Scotia, Clay Fraction Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:00 000. **$2.00**

OFM ME 1988-32 Till Geochemistry Map, Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

OFM ME 1988-31 Till Geochemistry Map, Pictou and Antigonish Counties (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

Map ME 1982-10 Pleistocene Geology and Till Geochemistry Map of Southwestern Nova Scotia (Sheets 7 and 8), by R. R. Stea and D. R. Grant, scale 1:100 000, (Sheet 9 is Map 1630A in Geological Survey of Canada Paper 85-17). **$8.00**

Map ME 1982-1 Pleistocene Geology and Till Geochemistry Map of South-Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000, (Sheet 5 is in Open File Report ME 555). **$3.50**

Map ME 1981-1 Pleistocene Geology and Till Geochemistry Map, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 are in Paper ME 1979-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. **$3.50**

Detailed Scale

1:50 000

OFM ME 1988-52 Preliminary Till Geochemistry and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, scale 1:50 000. **$2.00**

GEOPHYSICS MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00**

1:500 000

Map ME 1979-3 Geological Map of Nova Scotia, Bouguer Gravity Anomaly Edition, by J. D. Keppie, scale 1:500 000, 1979, with Metamorphic and Structural Map Inserts by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50**

Regional Scale

1:125 000

Map ME 1983-2 Calculated Vertical Magnetic Gradient Map of the Cape Breton Highlands, Inverness and Victoria Counties, Nova Scotia, scale 1:125 000. **$5.00**

Detailed Scale

1:50 000

OFM ME 1997-33 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/15, Port Mouton, Queens and Shelburne Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-32 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/14, Shelburne, Shelburne and Queens Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-31 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/13, Tusket, Yarmouth and Shelburne Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-30 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20O/16, Yarmouth, Yarmouth County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-28 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/09, Chester, Lunenburg and Halifax Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-27 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/08, Lunenburg, Lunenburg County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-26 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/07, Bridgewater, Lunenburg and Queens Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-25 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/04, Wentworth Lake, Yarmouth and Digby Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-24 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/03, Lake Rossignol, Shelburne, Yarmouth, Queens and Digby Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-23 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/02, Liverpool, Queens and Lunenburg Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-22 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/01, LaHave Islands, Lunenburg County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-21 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/12, Halifax, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-20 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/05, Guysborough, Guysborough and Antigonish Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-19 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/04, Country Harbour, Guysborough County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-18 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/03 and 11F/06, Larrys River and Chedabucto Bay, Guysborough County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-17 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/08, Lochaber, Pictou, Guysborough, and Antigonish Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-16 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/04, Kennetcook, Hants County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-15 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/03, Shubenacadie, Halifax, Colchester and Hants Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-14 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/02, Upper Musquodoboit, Halifax, Guysborough and Colchester Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-13 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/01, Liscomb, Guysborough and Halifax Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-12 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS

Map Sheet 11D/16, Ecum Secum, Halifax and Guysborough Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-11 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/15, Tangier, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-10 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/14, Musquodoboit Harbour, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-9 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/13, Mount Uniacke, Halifax and Hants Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-8 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/11, West Chezzetcook, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-7 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/10, Owls Head, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

MINERAL DEPOSITS MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00**

1:1 000 000

!!!NEW!!! **OFM ME 1998-15** Map of Active Mines in Nova Scotia, by Ian McLellan, June 1998, 1 map, scale 1:1 000 000. **$5.00**

1:500 000

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Map ME 1991-1 Map of Gypsum and Anhydrite Resources in Nova Scotia, compiled by G. C. Adams, 1991, scale 1:500 000 (accompanies EGS ME 1991-1). **$5.00**

Map ME 1985-1 Industrial Mineral Commodities Map of the Province of Nova Scotia, compiled by John H. Fowler, 1985, scale 1:500 000. **$5.00**

Map ME 1983-5 Metallogenic Map of Nova Scotia, by A. K. Chatterjee, scale 1:500 000, 1983. **$5.00**

Map ME 1983-3 Salt and Potash Resources Map of Nova Scotia, by R. C. Boehner, scale 1:500 000 (accompanies Bulletin ME 5). **$2.00** (white print copies only)

Map ME 1979-2 Geological Map of Nova Scotia, Metallic Mineral Occurrence Edition, by J. D. Keppie, D. J. Gregory, A. K. Chatterjee and N. A. Lyttle, scale 1:500 000, 1979, with Structural and Metamorphic Map Inserts by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50**

Regional Scale

1:250 000

Map ME 1989-3 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 3 (Cape Breton Island), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-2 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 2 (Central Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-1 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 1 (Southwestern Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

1:125 000

Map ME 1985-6 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000 (locates and shows the type, quality and observed thickness of sand and gravel deposits). **$3.00**

Map ME 1985-3, Map ME 1985-4, Map ME 1985-5 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000, (locates and names aggregate pits and quarries). **$3.00 each, $10.00 set**

1:100 000

OFM ME 1986-49 to OFM ME 1986-56 Gold Compilation of the Meguma Terrane in Nova Scotia, by J. McMullin, G. Richardson, T. Goodwin, 8 maps, scale 1:100 000. **$2.00 each**

Detailed Scale

1:50 000

OFM ME 1991-5 to OFM ME 1991-18 Aggregate Potential of Cumberland and Colchester Counties, 14 Preliminary Map Sheets, scale 1:50 000 (11E/02, 11E/03, 11E/05, 11E/06, 11E/07, 11E/11, 11E/12, 11E/13, 11E/14, 21H/07, 21H/08, 21H/09, 21H/10, 21H/16), by G. Prime, 1991. **$2.00 per NTS Map Sheet**

1:6000

OFM ME 1990-2 Map of the Glencoe Limestone Deposit, Inverness County (11F/14), 1988 Diamond-Drilling; Diamond-Drill Holes and Sections, by R. H. MacDonald, scale 1:6000. **$2.00**

1:1600

Map ME 1990-3 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 830 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-2 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 730 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-1 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 630 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

1:70

Map ME 1984-1 Geological Map of the Cochrane Hill Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:70. **$8.00**

STRUCTURE/TECTONIC MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00**

1:500 000

Map ME 1982-11 Tectonic Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1982. **$5.00**

Map ME 1979-1 Geological Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1979, with Metamorphic and Structural Map Inserts, by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50**

LAND USE MAPS

Provincial Scale

1:500 000

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Detailed Scale

1:50 000

OFM ME 1989-5 to OFM ME 1989-9 Mineral Resource Land Use Maps for Lunenburg County, by D. B. Hopper and H. J. Gillis, 1989, 5 maps, scale 1:50 000. **$2.00 per map; $10.00 set**

OFM ME 1988-44 to OFM ME 1988-49 Mineral Resource Land Use Maps for Kings County (21A/10, 21A/15, 21A/16, 21H/01, 21H/01, 21H/02, 21H/08), by D. B. Hopper and H. J. Gillis, 1989, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-33 to OFM ME 1988-38 Mineral Resource Land Use Maps for Cape Breton County, by D. B. Hopper and H. J. Gillis, 1988, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-17 to OFM ME 1988-22 Mineral Resource Land Use Maps for Hants County, by D. B. Hopper and H. J. Gillis, 1988, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-1 to OFM ME 1988-12 Mineral Resource Land Use Maps for Halifax County, by D. B. Hopper and C. A. Dobson, 1988, 12 maps, scale 1:50 000. **$2.00 per map; $24.00 set**

GENERAL MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **Free**

1:1 000 000

!!!NEW!!!

OFM ME 1998-16 Index Map to Geological Survey of Canada Open File Geological Maps of Nova Scotia, 1969-1998, by K. D. Fraser, T. L. Lenfesty, 1998, scale 1:1 000 000. **$2.00**

!!!NEW!!!

OFM ME 1998-15 Map of Active Mines of Nova Scotia, by Ian McLellan, June, 1998, 1 map, scale 1:1 000 000. **$5.00**

1:640 000

Outside Publication ME 1989-1 Geological Highway Map of Nova Scotia, Second Edition, by Howard V. Donohoe, Jr., and R. G. Grantham, scale 1:640 000, 1989 (Atlantic Geoscience Society, Special Publication Number 1). **$3.50**

1:500 000

Claim Reference Map (compilation) of Nova Scotia, updated quarterly, scale 1:500 000. **$5.00**

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Regional Scale

1:250 000

Map ME 1979-10 A Topographic Map Book of the Province of Nova Scotia, Geological Edition, scale 1:250 000, 1979, 46 pages. **Out of Print, Available for Viewing Only**

Detailed Scale

1:31 680

Claim Reference Maps of Nova Scotia, undated, scale 1:31 680. **$1.00 per 1:50 000 NTS Map Sheet Quarter Section**

ACTS

Provincial legislation.

Mineral Resources Act and Regulations, S.N.S. 1990, c. 18. **$9.35**

Gypsum Mining Income Tax Act, R.S.N.S. 1979, c. 190. **$1.00**

Treasure Trove Act, 1954. **FREE**

ANNUAL REPORTS

Summary reports of the Department's activities and programs.

1993/94

Annual Report for the Fiscal Year Ending March 31, 1994, by Nova Scotia Department of Natural Resources, 1995, 89 pages. **FREE**

1992/93

Annual Report for the Fiscal Year Ending March 31, 1993, by Nova Scotia Department of Natural Resources, 1994, 83 pages. **FREE**

1991/92

Annual Report for the Fiscal Year Ending March 31, 1992, by Nova Scotia Department of Natural Resources, 1994, 77 pages. **FREE**

1990/91

Annual Report for the Fiscal Year Ending March 31, 1991, by Nova Scotia Department of Mines and Energy, 1992, 117 pages. **FREE**

BULLETINS

Detailed scientific reports on various geoscience topics on a regional or provincial basis.

Bulletin ME 7 Structure of the Canadian Appalachians, by J. D. Keppie, 1992, 89 pages, 3 maps, 3 figures in back pocket. **$8.00 (Microfiche $2.00)**

Bulletin ME 6 Evaluation of Nova Scotia's Peatland Resources, by A. R. Anderson and W. A. Broughm, 1988, 109 pages and 3 maps, scale 1:250 000. **$15.00**

Bulletin ME 5 Salt and Potash Resources in Nova Scotia, by R. C. Boehner, 1986, 346 pages, 8½" x 11" format, includes Nova Scotia Department of Mines and Energy Map ME 1983-3, scale 1:500 000. **$17.00 (Microfiche $5.00)**

Bulletin ME 4 Barite, Celestite and Fluorite in Nova Scotia, by G. W. Felderhof, 1978, 463 pages, 200 figures, 12 tables. **$13.00**

Bulletin ME 3 Assessment of Peat Moss Occurrences in Guysborough, Antigonish, Pictou, Colchester and Cumberland Counties, Nova Scotia, by D. R. Sutherland and F. S. Shea, 1976, 301 pages. **$7.00**

Bulletin ME 2 (Part 1) Limestones and Dolomites of Nova Scotia, Part I - Cape Breton Island, by F. S. Shea and D. A. Murray, 1969, 300 pages, 1 map. **$4.00**

Bulletin ME 2 (Part 2) Limestones and Dolomites of Nova Scotia, Part II - Antigonish, Guysborough, Pictou, and Cumberland Counties, by D. A. Murray, 1975, 155 pages. **$6.50**

Bulletin ME 1 Port Hawkesbury Project - Geology, Geochemistry and Groundwater Investigations of Southwest Inverness and Richmond Counties, Nova Scotia, by F. S. Shea and J. D. Wallace, 1962, 73 pages, 5 maps. **$2.00**

CONTRIBUTION SERIES

Detailed scientific papers on specific geoscience topics authored by Minerals and Energy Branch staff and published externally in scientific journals and monographs.

!!!NEW!!!

CS ME 1998-17 Stratigraphy and Tectonic Significance of the Lower to Middle Devonian McAdams Lake Formation, Cape Breton Island, Nova Scotia, by C. E. White, and S. M. Barr, *in* Atlantic Geology, 34, p. 133-145. **FREE**

!!!NEW!!!

CS ME 1998-16 Wisconsinan Glacial and Sea-Level History of Maritime Canada and the Adjacent Continental Shelf: A Correlation of Land and Sea Events, by R. R. Stea, D. J. W. Piper, G. B. J. Fader, and R. Boyd; *in* GSA Bulletin, July 1998, v. 110, p. 821-845. **FREE**

!!!NEW!!!

CS ME 1998-15 Origin and Evolution of the Greisenizing Fluid at the East Kemptville Tin Deposit, Nova Scotia, Canada, by W. E. Halter, A. E. Williams-Jones, and D. J. Kontak, Nova Scotia Department of Natural Resources; *in* Economic Geology, v. 93, 1998, p. 1026-1051. **FREE**

!!!NEW!!!

CS ME 1998-14 The Carboniferous Evolution of Nova Scotia, by J. H. Calder; *in* Geological Society, Special Publication 143, Lyell: the Past is the Key to the Present, eds. D. J. Blundell and A. C. Scott. **FREE**

!!!NEW!!!

CS ME 1998-13 40Ar/39Ar Dating of Ribbon-Textured Veins and Wall-Rock Material from Meguma Lode Gold Deposits, Nova Scotia: Implications for Timing and Duration of Vein Formation in Slate-Belt Hosted Vein Gold Deposits, by D. J. Kontak, R. J. Horne, H. Sandeman, D. Archibald, and J. K. W. Lee; *in* Canadian Journal of Earth Science, 35 (1998), p. 746-761. **FREE**

!!!NEW!!!

CS ME 1998-12 Geology of the B Baseline Zone, Walton Cu-Pb-Zn-Ag-Ba Deposit, Nova Scotia, Canada, by D. F. Sangster, M. D. Burtt, D. J. Kontak; *in* Economic Geology, v. 93, 1998, p. 869-982. **FREE**

!!!NEW!!!

CS ME 1998-11 A Genetic Model for Mineralization of Lower Windsor (Viséan) Carbonate Rocks of Nova Scotia, Canada, by D. F. Sangster, M. M. Savard and D. J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 932-952. **FREE**

!!!NEW!!!

CS ME 1998-10 Sub-Basin-Specific Pb and Sr Sources in Zn-Pb Deposits of the Lower Windsor Group, Nova Scotia, Canada, by D. F. Sangster, M. M. Savard and D. J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 911-919. **FREE**

!!!NEW!!!

CS ME 1998-9 Fluid Composition and Thermal Regime during Zn-Pb Mineralization in the Lower Windsor Group, Nova Scotia, Canada, by Guoxiang Chi, Daniel J. Kontak and Anthony E. Williams-Jones; *in* Economic Geology, vol. 93, 1998, p. 883-895. **FREE**

!!!NEW!!!

CS ME 1998-8 $\delta^{13}C$-$\delta^{18}O$-$^{87}Sr/^{86}Sr$ Covariations in Ore-Stage Calcites at and around the Gays River Zn-Pb Deposit (Nova Scotia, Canada) - Evidence for Fluid Mixing, by Martine M. Savard and Daniel J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 818-833. **FREE**

!!!NEW!!!

CS ME 1998-7 Aqueous and Liquid Petroleum Inclusion in Barite from the Walton Deposit, Nova Scotia Canada: A Carbonate-Hosted Ba-Pb-Zn-Cu-Ag Deposit, by Daniel J. Kontak and D. F. Sangster; *in* Economic Geology, vol. 93, 1998, p. 845-868. **FREE**

!!!NEW!!!

CS ME 1998-6 A Study of Fluid Inclusions in Sulfide and Nonsulfide Mineral Phases from a Carbonate-Hosted Zn-Pb Deposit, Gays River, Nova Scotia, Canada, by Daniel J. Kontak; *in* Economic Geology, vol. 93, 1998, p. 793-817. **FREE**

!!!NEW!!!

CS ME 1998-5 Modeling Fluid-Rock Interaction During Greisenization at the East Kemptville Tin Deposit: Implications for Mineralization, by Werner E. Halter, Anthony E. Williams-Jones and Daniel J. Kontak; *in* Chemical Geology, 150 (1998), p. 1-17. **FREE**

CS ME 1998-4 A review of mesothermal gold deposits of the Meguma Group, Nova Scotia, Canada, by R. J. Ryan, P. K. Smith, Nova Scotia Department of Natural Resources; *in* Ore Geology Reviews 13 (1988), pages 153-183.**FREE**

CS ME 1998-3 Earth Science and Engineering: Urban Development in Metropolitan Halifax Region, by C. F. Michael Lewis, Brian B. Taylor, Rudolph R. Stea, Gordon B. J. Fader, Richard J. Horne, S. Greg MacNeill and Joe G. Moore; *in* Urban Geology of Canadian Cities, edited by P. F. Karrow and O. L. White, Geological Society of Canada, Special Paper 42, 1998, p. 409-444, 5 coloured maps. **$5.00**

CS ME 1998-2 Deglaciation of Nova Scotia: Stratigraphy and Chronology of Lake Sediment Cores and Buried Organic Section, by Rudolph R. Stea and Robert J. Mott; *in* Geographie physique at Quaternaire, 1998, v. 52, no. 1, p. 3-21. **FREE**

CS ME 1998-1 Gold and Base Metals Highlight Exploration in 1997, by Paul D. McCulloch; presented at the Prospectors and Developers Association Meeting, March 1998. **FREE**

CS ME 1997-3 Lithogeochemical Characterization of the Beaverbank Unit of the Halifax Formation, Meguma Group, and Acid Drainage Implications, by M. Feetham, R. J. Ryan, G. Pe-Piper and A. M. O'Beirne-Ryan; *in* Atlantic Geology, vol. 33, 1997, p. 133-141. **FREE**

CS ME 1997-2 Alkali Feldspar in the Peraluminous South Mountain Batholith, Nova Scotia: Trace Element Data, by Daniel J. Kontak and Robert F. Martin; *in* The Canadian Mineralogist, vol. 35, 1997, p. 959-977. **FREE**

CS ME 1997-1 An Isotopic (C, O, Sr) Study of Vein Gold Deposits in the Meguma Terrane, Nova Scotia: Implication for Source Reservoirs, by Daniel J. Kontak and Robert Kerrich; *in* Economic Geology, v. 92, 1997, p. 161-180. **FREE**

CS ME 1996-5 The Westphalian D Fossil Lepidodendrid Forest at Table Head, Sydney Basin, Nova Scotia: Sedimentology, Paleoecology and Floral Response to Changing Edaphic Conditions, by J. H. Calder, M. R. Gibling, C. F. Eble, A. C. Scott and D. J. MacNeil; *in* International Journal of Coal Geology, v. 31, 1996, p. 277-313. **FREE**

CS ME 1996-4 Hydrothermal Characterization of the West Gore Sb-Au Deposit, Meguma Terrane, Nova Scotia, Canada, by Daniel J. Kontak, Richard J. Horne and Paul K. Smith; *in* Economic Geology, v. 91, 1996, p. 1239-1262. **FREE**

CS ME 1996-3 The Role of Greisenization in Cassiterite Precipitation at the East Kemptville Tin Deposit, Nova Scotia, by Werner E. Halter, Anthony E. Williams-Jones and Daniel J. Kontak; *in* Economic Geology, v. 91, 1996, p. 368-385. **FREE**

CS ME 1996-2 Deglaciation of the Inner Scotian Shelf, Nova Scotia: Correlation of Terrestrial and Marine Glacial Events, by R. R. Stea, R. Boyd, O. Costello, G. B. J. Fader and D. B. Scott; *in* Late Quaternary Palaeoceanography of the North Atlantic Margins, Geological Society Special Publication no. 111, 1996, p. 77-101. **FREE**

CS ME 1996-1 Patterns of Phosphorus Enrichment in Alkali Feldspar, South Mountain Batholith, Nova Scotia, Canada, by Daniel J. Kontak, Robert F. Martin and Linda Richard; *in* European Journal of Mineralogy, v. 8, 1996, p. 805-824. **FREE**

CS ME 1995-6 Mineral Chemistry and ^{40}Ar/^{39}Ar Dating of Muscovite from the East Kemptville Leucogranite, Southern Nova Scotia: Evidence for Localized Resetting of ^{40}Ar/^{39}Ar Systematics in a Shear Zone, by Daniel J. Kontak, Edward Farrar, Sandra McBride and Robert F. Martin; *in* The Canadian Mineralogist, v. 33, p. 1237-1253. **FREE**

CS ME 1995-5 The Near-Surface Geology of St. Georges Bay, Nova Scotia: Implications for the Hollow Fault, by P. Durling, K. Howells and P. Harvey; *in* Canadian Journal of Earth Sciences, v. 32, 1995, p. 603-613. **FREE**

CS ME 1995-4 Geological and Geochemical Studies of a Metaturbidite-Hosted Lode Gold Deposit: The Beaver Dam Deposit, Nova Scotia, by Daniel J. Kontak and Robert Kerrich; *in* Economic Geology, v. 90, 1995, p. 885-901. **FREE**

CS ME 1995-3 The Thermal Evolution and Timing of Hydrocarbon Generation in the Maritimes Basin of Eastern Canada: Evidence from Apatite Fission Track Data, by A. M. Grist, R. J. Ryan and M. Zentilli; *in* Bulletin of Canadian Petroleum Geology, v. 43, no. 2, June 1995, p. 145-155. **FREE**

CS ME 1995-2 Geological Setting of Industrial Mineral Deposits in the Maritime Provinces of Eastern Canada, by R. J. Ryan; *in* Proceedings: 30th Forum on the Geology of Industrial Minerals (1994), edited by Shasta A. A. Merlini; New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Miscellaneous Report 16, 1995, p. 180-193. **FREE**

CS ME 1995-1 Laser-Ablation ICP-MS Micro-Analysis of Calcite Cement from a Mississippi-Valley-Type Zn-Pb Deposit, Nova Scotia: Dramatic Variability in REE Content on Macro- and Micro-Scales, by Daniel J. Kontak and Simon Jackson; *in* The Canadian Mineralogist, v. 33, 1995, p. 445-467. **FREE**

CS ME 1994-10 Origin of Topaz-Bearing and Related Peraluminous Granites of the Late Devonian Davis Lake Pluton, Nova Scotia, Canada: Crystal Versus Fluid Fractionation, by J. Dostal and A. K. Chatterjee; *in* Chemical Geology including Isotope Geoscience, v. 123, 1995, p. 67-88. **FREE**

CS ME 1994-9 Gold Environments in Nova Scotia: Some changes in Thinking, by P. K. Smith, A. K. Chatterjee and M. A. MacDonald; *in* Proceedings of the 107th Annual General Meeting, The Mining Society of Nova Scotia, June 29 to July 1, 1994. **FREE**

CS ME 1994-8 Carboniferous Fossil Forests, by Andrew C. Scott and John H. Calder; *in* Geology Today, November-December 1994, p. 213-217. **FREE**

CS ME 1994-7 ^{40}Ar/^{39}Ar Dating of Metamorphic and Igneous Rocks of the Liscomb Complex, Meguma Terrane, Southern Nova Scotia, Canada, by D. J. Kontak and P. H. Reynolds; *in* Canadian Journal of Earth Sciences, v. 31, 1994, p. 1643-1653. **FREE**

CS ME 1994-6 ^{40}Ar/^{39}Ar Dating of Fluid Migration in a Mississippi Valley-Type Deposit: The Gays River Zn-Pb Deposit, Nova Scotia, Canada, by Daniel J. Kontak, Edward Farrar and Sandra L. McBride; *in* Economic Geology, v. 89, 1994, p. 1501-1517. **FREE**

CS ME 1994-5 Relict and Palimpsest Glacial Landforms in Nova Scotia, Canada, by R. R. Stea; *in* Formation and Deformation of Glacial Deposits, Proceedings of the Meeting of the Commission on the Formation and Deformation of Glacial Deposits, May 1991, p. 141-158. **FREE**

CS ME 1994-4 Geological and Geochemical Studies of Alteration Processes in a Fluorine-Rich Environment: The East Kemptville Sn- (Zn-Cu-Ag) Deposit, Yarmouth County, Nova Scotia, Canada, by Daniel J. Kontak; *in* Alteration and Alteration Processes Associated with Ore-Forming Systems, Geological Association of Canada, Short Course Notes, v. 11, 1994, p. 261-314. **FREE**

CS ME 1994-3 The Euramerican Coal Province: Controls on Late Paleozoic Peat Accumulation, by J. H. Calder and M. R. Gibling; *in* Palaeogeography, Palaeoclimatology, Palaeoecology, v. 106, 1994, p. 1-21. **FREE**

CS ME 1994-2 Morphology and Seismic Stratigraphy of the Inner Continental Shelf off Nova Scotia, Canada: Evidence for a -65 m Lowstand between 11,650 and 11,250 C^{14} yr. B.P., by R. R. Stea, R. Boyd, G. B. J. Fader, R. C. Courtney, D. B. Scott and S. S. Pecore; *in* Marine Geology, v. 117, 1994, p. 135-154. **FREE**

CS ME 1994-1 The Impact of Climate Change, Tectonism and Hydrology on the Formation of Carboniferous Tropical Intermontane Mires: the Springhill Coalfield, Cumberland Basin, Nova Scotia, by John H. Calder; *in* Palaeogeography, Palaeoclimatology, Palaeoecology, 106, 1994, p. 323-351. **FREE**

CS ME 1993-11 Allocyclic and Thermochronological Constraints on the Evolution of the Maritimes Basin of Eastern Canada, by R. J. Ryan and M. Zentilli; *in* Atlantic Geology, v. 29, 1993, p. 187-197. **FREE**

CS ME 1993-10 Geological, Geochemical and Isotopic Studies of the East Kemptville Sn - (Zn-Cu-Ag) Deposit, Yarmouth County, Nova Scotia, Canada, by Daniel J. Kontak; *in* Proceedings of the Eighth Quadrennial IAGOD Symposium, 1993, p. 383-409. **FREE**

CS ME 1993-9 The Evolution of a Ground Water-Influenced (Westphalian B) Peat-Forming Ecosystem in a Piedmont Setting: The No. 3 Seam, Springhill Coalfield, Cumberland Basin, Nova Scotia, by J. H. Calder; *in* Geological Society of America, Special Paper 286, 1993, p. 153-180. **FREE**

CS ME 1993-8 Synthesis of Palaeozoic Deformational Events and Terrane Accretation in the Canadian Appalachians, by J. D. Keppie; *in* Geol. Rundsch., v. 82, 1993, p. 381-431. **FREE**

CS ME 1993-7 Trace Element Chemistry of Vegetation Applied to Mineral Exploration in Eastern Nova Scotia, Canada, by P. J. Rogers and C. E. Dunn; *in* Journal of Geochemical Exploration, v. 48, 1993, p. 71-95. **FREE**

CS ME 1993-6 Multi-Media Geochemistry and Surficial Geology of the Yava Pb Deposit, Southeastern Cape Breton Island, Nova Scotia, Canada, by M. A MacDonald and F. J. Boner; *in* Journal of Geochemical Exploration, v. 48, 1993, p. 39-69. **FREE**

CS ME 1993-5 A Metaturbidite-Hosted Lode Gold Deposit: The Beaver Dam Deposit, Nova Scotia. 1. Vein Paragenesis and Mineral Chemistry, by Daniel J. Kontak and Paul K. Smith; *in* Canadian Mineralogist, v. 31, 1993, p. 471-522. **FREE**

CS ME 1993-4 ^{40}Ar/^{39}Ar Mineral Ages from the Southern Cape Breton Highlands and Creignish Hills, Cape Breton Island, Canada: Evidence for a Polyphase Tectonothermal Evolution, by R. David Dallmeyer and J. Duncan Keppie; *in* The Journal of Geology, v. 101, 1993, p. 467-482. **FREE**

CS ME 1993-3 ^{14}S Enrichment in Late-Stage Veins, East Kemptville Tin and Base Metal Deposit, Nova Scotia, Canada: Evidence for Late Incursion of Metasedimentary - Processed Sulfur in a Magmatic System, by Daniel J. Kontak; *in* Economic Geology, v. 88, 1993, p. 203-207. **FREE**

CS ME 1993-2 Geology and ^{40}Ar/^{39}Ar Geochronology of the Beaver Dam Gold Deposit, Meguma Terrane, Nova Scotia, Canada: Evidence for Mineralization at 370 Ma, by Daniel J. Kontak, Paul K. Smith, and Peter H. Reynolds; *in* Economic Geology, v. 88, 1993, p. 139-170. **FREE**

CS ME 1993-1 Dating Mineralization Using Several Isotopic Methods: An Example from the South Mountain Batholith, Nova Scotia, Canada, by J. D. Keppie, R. D. Dallmeyer, T. E. Krogh and M. Aftalion; *in* Chemical Geology, v. 103, 1993, p. 251-270. **FREE**

CS ME 1992-15 Control on Formation of Upper Carboniferous Coals in the Intermontane Stellarton and Cumberland Basins of Atlantic Canada, by R. D. Naylor, J. H. Calder, R. J. Ryan and T. A. Mortel; *in* Canadian Coal and Coalbed Methane Geoscience Forum, Part 2: Forum Proceedings, edited by B. Ryan, J. Cunningham, 1992, p. 365-397. **FREE**

CS ME 1992-14 Quaternary Seismic Stratigraphy of the Inner Shelf Region, Eastern Shore, Nova Scotia, by R. R. Stea, G. B. J. Fader and R. Boyd; *in* Current Research, Part D, Eastern Canada and National and General Programs, Geological Survey of Canada, Paper no. 92-01D, 1992, p. 179-188. **FREE**

CS ME 1992-13 The Pre-Late Wisconsinan Chronology of Nova Scotia, Canada, by R. R. Stea, R. J. Mott, D. F. Belknap and U. Radtke; *in* The Last Interglacial - Glacial Transition in North America, edited by P. U. Clarke, P. D. Lea, Geological Society of America, Special Paper no. 270, 1992, p. 185-205. **FREE**

CS ME 1992-12 Structure and Emplacement of the South Mountain Batholith, Southwestern Nova Scotia, by R. J. Horne, M. A. MacDonald, M. C. Corey and L. J. Ham; *in* Atlantic Geology, v. 28, 1992, p. 29-50. **FREE**

CS ME 1992-11 The Paleozoic Maritimes Basin of Eastern Canada: Metallogenetic Implications of a Fission Track Study, by R. J. Ryan, A. M. Grist and M. Zentilli; *in* Mineralogical Association of Canada, Short Course Handbook, v. 20, 1992, p. 141-155. **FREE**

CS ME 1992-10 Geological Features within the Big Indian Lake Pluton, Hants County, Nova Scotia: Evidence of Igneous Layering from Recent Diamond-Drilling, by M. C. Corey; *in* Atlantic Geology, v. 28, 1992, p. 51-62. **FREE**

CS ME 1992-9 Petrographic and Geochemical Evidence for a Hypogene Origin of Granite-Hosted, Vein-Type Mn Mineralization at the New Ross Mn Deposits, Lunenburg County, Nova Scotia, Canada, by G. A. O'Reilly; *in* Economic Geology, v. 87, 1992, p. 1275-1300. **FREE**

CS ME 1992-8 Correlation of Neoproterozoic III Sequences in the Avalon Composite Terrane of Mainland Nova Scotia: Tectonic Implications, by J. Brendan Murphy, Georgia Pe-Piper, J. Duncan Keppie and David J. W. Piper; *in* Atlantic Geology, v. 28, 1992, p. 143-151. **FREE**

CS ME 1992-7 Late Carboniferous and Early Permian Drainage Patterns in Atlantic Canada, by Martin R. Gibling, John H. Calder, Robert Ryan, H. Walter Van De Poll and Gary M. Yeo; *in* Canadian Journal of Earth Sciences, v. 29, 1992, p. 338-352. **FREE**

CS ME 1992-6 The East Kemptville Tin Deposit, Yarmouth County, Nova Scotia: A Pb Isotope Study of the Leucogranite and Mineralized Greisens - Evidence for a 366 Ma Metallogenic Event, by D. J. Kontak and A. K. Chatterjee; *in* Canadian Journal of Earth Sciences, v. 29, no. 6, 1992, p. 1180-1196. **FREE**

CS ME 1992-5 An Overview of Recent Bedrock Mapping and Follow-Up Petrological Studies of the South Mountain Batholith, Southwestern Nova Scotia, Canada, by Michael A. MacDonald, Richard J. Horne, Michael C. Corey and Linda J. Ham; *in* Atlantic Geology, v. 28, 1992, p. 7-28. **FREE**

CS ME 1992-4 The East Kemptville Tin Deposit, Yarmouth County, Southwestern Nova Scotia: A Lithogeochemical Study of the Wallrock Metasedimentary Rocks, by Daniel J. Kontak and Jarda Dostal; *in* Atlantic Geology, v. 28, 1992, p. 63-83. **FREE**

CS ME 1992-3 Some Geochemical Consequences of Environmental Change and Human Activity in Nova Scotia, Canada, by Peter J. Rogers and J. Gordon Ogden, III; *in* Transactions of the Institution of Mining and Metallurgy, v. 101, 1992, p. B15-B24. **FREE**

CS ME 1992-2 U-Pb and $^{40}Ar/^{39}Ar$ Mineral Ages from Cape North, Northern Cape Breton Island: Implications for Accretion of the Avalon Composite Terrane, by J. D. Keppie, R. D. Dallmeyer and T. E. Krogh; *in* Canadian Journal of Earth Sciences, v. 29, 1992, p. 277-295. **FREE**

CS ME 1992-1 Geochemistry of Mineralized and Barren, Late Proterozoic Felsic Volcanic Rocks in Southeastern Cape Breton Island, Nova Scotia (Canada), by J. Dostal, J. D. Keppie and M. Zhai; *in* Precambrian Research, v. 56, 1992, p. 33-49. **FREE**

CS ME 1991-15 Hydrocarbon Generation from Deltaic and Intermontane Fluviodeltaic Coal and Coaly Shale from the Tertiary of Texas and Carboniferous of Nova Scotia, by P. K. Mukhopadhyay, P. G. Hatcher and J. H. Calder; *in* Organic Geochemistry, v. 17, no. 6, 1991, p. 765-783. **FREE**

CS ME 1991-14 Contrasting U-Pb Ages from Plutons in the Bras d'Or and Mira Terranes of Cape Breton Island, Nova Scotia: Discussion, by J. D. Keppie and R. D. Dallmeyer; *in* Canadian Journal of Earth Sciences, v. 28, p. 1493-1494. **FREE**

CS ME 1991-13 Chemical and Isotopic Composition of the Lower Crust beneath the Meguma Lithotectonic Zone, Nova Scotia: Evidence from Granulite Facies Xenoliths, by G. W. Eberz, D. B. Clarke, A. K. Chatterjee and P. S. Giles; *in* Contribution to Mineralogy and Petrology, v. 109, 1991, p. 69-88. **FREE**

CS ME 1991-12 Composition and Depositional Environment of Major Eastern Canadian Oil Shales, by W. D. Smith, C. J. St. Peter, R. D. Naylor, P. K. Mukhopadhyay, W. D. Kalkreuth, F. D. Ball and G. Macauley; *in* International Journal of Coal Geology, v. 19, 1991, p. 385-438. **FREE**

CS ME 1991-11 The Relationship Between Coal Petrography and Depositional Environments from Selected Coal Basins in Canada, by W. D. Kalkreuth, D. L. Marchioni, J. H. Calder, M. N. Lamberson, R. D. Naylor and J. Paul; *in* International Journal of Coal Geology, v. 19, 1991, p. 21-76. **FREE**

CS ME 1991-10 Lithostratigraphic Revisions of the Upper Carboniferous to Lower Permian Strata in the Cumberland Basin, Nova Scotia, and the Regional Implications for the Maritimes Basin in Atlantic Canada, by R. J. Ryan, R. C. Boehner and J. H. Calder; *in* Bulletin of Canadian Petroleum Geology, v. 39, no. 4, 1991, p. 289-314. **FREE**

CS ME 1991-9 Deep Seismic Reflection Data from the Bay of Fundy and Gulf of Maine: Tectonic Implications for the Northern Appalachians, by C. E. Keen, W. A. Kay, D. Keppie, F. Marillier and G. Pe-Piper and J. W. F. Waldron; *in* Canadian Journal of Earth Sciences, v. 28, 1991, p. 1096-1111. **FREE**

CS ME 1991-8 Use of Nonparametric Ranking Statistics to Characterize Magmatic and Post-Magmatic Processes in the Eastern South Mountain Batholith, Nova Scotia, Canada, by M. A. MacDonald and D. B. Clarke; *in* Chemical Geology, v. 92, 1991, p. 1-20. **FREE**

CS ME 1991-7 Reconnaissance and Detailed Geochemical Surveys for Gold in Eastern Nova Scotia using Plants, Lake Sediment, Soil and Till, by C. E. Dunn, W. B. Coker and P. J. Rogers; *in* Journal of Geochemical Exploration, v. 40, 1991, p. 143-163. **FREE**

CS ME 1991-6 Late Proterozoic Tectonic Model for the Avalon Terrane in Maritime Canada, by J. Duncan Keppie and J. Dostal; *in* Tectonics, v. 10, no. 4, 1991, p. 842-850. **FREE**

CS ME 1991-5 Northern Appalachians: Avalon and Meguma Terranes, by J. D. Keppie, R. D. Nance, J. B. Murphy and J. Dostal; *in* The West African Orogens and Circum-Atlantic Correlatives, by R. D. Dallmeyer and J. P. LeCorche, 1991, p. 315-334. **FREE**

CS ME 1991-4 The Role of Fluids in the Late-Stage Evolution of the South Mountain Batholith, Nova Scotia: Further Geochemical and Oxygen Isotopic Studies, by Daniel J. Kontak, Robert Kerrich and David F. Strong; *in* Atlantic Geology, v. 27, 1991, p. 29-47. **FREE**

CS ME 1991-3 Geochronological Evidence for Multiple Tectono-Thermal Overprinting Events in the East Kemptville Muscovite - Topaz Leucogranite, Yarmouth County, Nova Scotia, Canada, by D. J. Kontak and R. F. Cormier; *in* Canadian Journal of Earth Sciences, v. 28, no. 2, 1991, p. 209-224. **FREE**

CS ME 1991-2 Peat Formation in a Westphalian B Piedmont Setting, Cumberland Basin, Nova Scotia: Implications for the Maceral-Based Interpretation of Rheotrophic and Raised Paleomires, by John H. Calder, Martin R. Gibling and Prasanta K. Mukhopadhyay; *in* Bulletin de la Societe Géologique de France, 1991, t.162, no. 2, p. 283-298. **FREE**

CS ME 1991-1 The East Kemptville Topaz-Muscovite Leucogranite, Nova Scotia. II. Mineral Chemistry, by Daniel J. Kontak; *in* Canadian Mineralogist, v. 29, 1991, p. 153-174. **FREE**

CS ME 1990-16 The Avalon Composite Terrane of Nova Scotia by J. B. Murphy, J. D. Keppie, R. D. Nance and J. Dostal; *in* Avalonian and Cadomian Geology of the North Atlantic, edited by R. A. Strachan, G. K. Taylor, 1990, p. 195-213. **FREE**

CS ME 1990-15 Geological and ^{40}Ar/^{39}Ar Geochemical Constraints on the Timing of Quartz Vein Formation in Meguma Group Lode-Gold Deposits, Nova Scotia, by D. J. Kontak, P. K. Smith, P. Reynolds and K. Taylor; *in* Atlantic Geology, v. 26, 1990, p. 201-227. **FREE**

CS ME 1990-14 Comment and Reply on "Tectono-Stratigraphic Terranes in Cape Breton Island, Nova Scotia: Implications for the Configuration of the Northern Appalachian Orogen", by J. D. Keppie; *in* Geology, v. 18, 1990, no. 7, p. 669-671. **FREE**

CS ME 1990-13 Age of Detrital Zircon and Titanite in the Meguma Group, Southern Nova Scotia, Canada: Clues to the Origin of the Meguma Terrane, by T. E. Krogh and J. D. Keppie; *in* Tectonophysics, v. 177, p. 307-323. **FREE**

CS ME 1990-12 A Sulfur Isotope Study of Main-Stage Tin and Base Metal Mineralization at the East Kemptville Tin Deposit, Yarmouth County, Nova Scotia, Canada: Evidence for Magmatic Origin of Metals and Sulfur, by Daniel J. Kontak; *in* Economic Geology, v. 85, 1990, p. 399-407. **FREE**

CS ME 1990-11 Metallogenic Domains and their Reflection in Regional Lake Sediment Surveys from the Meguma Zone, Southern Nova Scotia, Canada, by Peter J. Rogers, Amulaya K. Chatterjee and Jeffrey W. Aucott; *in* Journal of Geochemical Exploration, v. 39, 1990, p. 153-174. **FREE**

CS ME 1990-10 Fluorescence Properties of Alginite-Rich Oil Shales from the Stellarton Basin, Canada, by W. Kalkreuth, R. Naylor, K. Pratt and W. Smith; *in* Fuel, v. 69, February 1990, p. 139-144. **FREE**

CS ME 1990-9 Seismic Modelling of Porosity Within the Jurassic Age Carbonate Bank, Offshore Nova Scotia, by Paul J. Harvey and D. Jack MacDonald; *in* Canadian Journal of Exploration Geophysics, v. 26, no. 1 and 2, 1990, p. 54-71. **FREE**

CS ME 1990-8 Exploration Drilling of Evaporites: Procedures Developed in Eastern Canada, by D. C. Carter and J. P. Anderle; *in* CIM Bulletin, July 1990, p. 103-112. **FREE**

CS ME 1990-7 Characteristics of REE and Other Trace Elements in Response to Successive and Superimposed Metasomatism Within a Portion of the South Mountain Batholith, Nova Scotia, Canada, by Michael C. Corey and A. K. Chatterjee; *in* Chemical Geology, v. 85, 1990, p. 265-285. **FREE**

CS ME 1990-6 Geochemistry of Late Proterozoic Basaltic Rocks from Southeastern Cape Breton Island, Nova Scotia, by J. Dostal, J. D. Keppie and J. B. Murphy; *in* Canadian Journal of Earth Sciences, v. 27, 1990, p. 619-631. **FREE**

CS ME 1990-5 The Geochemistry and Petrology of the Late Precambrian Georgeville Group: Volcanic Arc - Rift Succession in the Avalon Terrane of Nova Scotia, by J. B. Murphy, J. D. Keppie, J. Dostal and A. J. Hynes; *in* The Cadomian Orogeny, edited by R. S. D'Lemos, R. A. Strachan and C. G. Topley, 1990, Geological Society Special Publication no. 51, p. 383-393. **FREE**

CS ME 1990-4 Interpretation of Till Geochemical Data in Nova Scotia, Canada, Using Mapped Till Units, Multi-Element Anomaly Patterns, and the Relationship of Till Clast Geology to Matrix Geochemistry, by R. G. Turner and R. R. Stea; *in* Journal of Geochemical Exploration, v. 37, 1990, p. 225-254. **FREE**

CS ME 1990-2 Tectonic Implications of ^{40}Ar/^{39}Ar Hornblende Ages from Late Proterozoic-Cambrian Plutons in the Avalon Composite Terrane, Nova Scotia, Canada, by J. Duncan Keppie, R. D. Dallmeyer and J. Brendan Murphy; *in* Geological Society of American Bulletin, v. 102, 1990, p. 516-528. **FREE**

CS ME 1990-1 The East Kemptville Topaz-Muscovite Leucogranite, Nova Scotia: Geological Setting and Whole-Rock Geochemistry, by Daniel J. Kontak; *in* Canadian Mineralogist, v. 28, 1990, p. 787-825. **FREE**

CS ME 1989-16 Tourmaline Composition as a Guide to Mineral Exploration: A Reconnaissance Study from Nova Scotia using Discriminant Function Analysis, by D. B. Clarke, N. C. Reardon, A. K. Chatterjee and D. C. Gregoire; *in* Economic Geology, v. 84, 1989, p. 1921-1935. **FREE**

CS ME 1989-15 Stratigraphy, Sedimentology and Depositional Environments of the Coal-Bearing Stellarton Formation, Nova Scotia, by R. D. Naylor, W. D. Kalkreuth, W. D. Smith and G. M. Yeo; *in* Contributions to Canadian Coal Geoscience; Geological Survey of Canada, Paper 89-08, 1989, p. 2-13. **FREE**

CS ME 1989-14 Geology, Geochemistry, and Exploration Applications for the Permo-Carboniferous Redbed Copper Deposits of the Cumberland Basin, Nova Scotia, Canada, by R. J. Ryan, R. C. Boehner, R. R. Stea and P. J. Rogers; *in* Geological Association of Canada, Special Paper 36, 1989, p. 245-256. **FREE**

CS ME 1989-13 Palynology and Stratigraphy of the Lower Carboniferous Horton Group, Nova Scotia, by J. Utting, J. D. Keppie and P. S. Giles; *in* Contributions to Canadian Paleontology, edited by L. Reynolds; Geological Survey of Canada, Bulletin no. 396, 1989, p. 117-143. **FREE**

CS ME 1989-12 ^{40}Ar/^{39}Ar Mineral Ages from Kellys Mountain, Cape Breton Island, Nova Scotia: Implications for the Tectonothermal Evolution of the Avalon Composite Terrain, by J. D. Keppie and R. D. Dallmeyer; *in* Canadian Journal of Earth Sciences, v. 26, 1989, no. 8, p. 1509-1516. **FREE**

CS ME 1989-11 Sulphur Isotopic Composition of Sulphides from the Beaver Dam and other Meguma Group Hosted Gold Deposits, Nova Scotia: Implication for Genetic Models, by D. J. Kontak and P. K. Smith; *in* Canadian Journal of Earth Sciences, v. 26, no. 8, 1989, p. 1617-1629. **FREE**

CS ME 1989-10 Petrology, Rock-Eval and Facies Analyses of the McLeod Coal Seam and Associated Beds, Pictou Coalfield, Nova Scotia, Canada, by J. Paul, W. Kalkreuth, R. Naylor and W. Smith; *in* Atlantic Geology, v. 25, 1989, p. 81-92. **FREE**

CS ME 1989-9 Deglaciation Environments and Evidence for Glaciers of Younger Dryas Age in Nova Scotia, Canada, by Rudolph R. Stea and Robert J. Mott; *in* Boreas, v. 18, p. 169-187. **FREE**

CS ME 1989-8 Downhole Geophysics as an Aid to the Interpretation of an Evaporite Sequence: Examples from Nova Scotia, by D. C. Carter; *in* CIM Bulletin, v. 82, no. 925, p. 58-64. **FREE**

CS ME 1989-7 Variation in Drumlin Orientation, Form and Stratigraphy Relating to Successive Ice Flows in Southern and Central Nova Scotia, by R. R. Stea and Y. Brown; *in* Sedimentary Geology, v. 62, 1989, p. 223-240. **FREE**

CS ME 1989-6 Northern Appalachian Terranes and Their Accretionary History, by J. D. Keppie; *in* Geological Society of America, Special Paper 230, 1989, p. 159-192. **FREE**

CS ME 1989-5 Carbonate Bioherms in the Kennetcook and Herbert River Limestone Members, Upper Part of the Windsor Group, Central Mainland Nova Scotia, by R. C. Boehner, R. J. Horne, R. J. Ryan; *in* Reefs, Canada and Adjacent Areas, Canadian Society of Petroleum Geologists, Memoir 13, 1989, p. 622-625. **FREE**

CS ME 1989-4 A Lacustrine Limestone Mound (Algal Reef) in the Wilkie Brook Formation (Horton Group), Cape George Area, Northeastern Mainland Nova Scotia, by R. C. Boehner and B. E. MacBeath; *in* Reefs, Canada and Adjacent Areas, Canadian Society of Petroleum Geologists, Memoir 13, 1989, p. 626-630. **FREE**

CS ME 1989-3 Carbonate Buildups of Windsor Group Major Cycle 2: Maxner and Miller Limestones, Miller Creek Formation and Mosher Road Member, Elderbank Formation and B$_2$ Limestone, Nova Scotia, by R. C. Boehner; *in* Reefs, Canada and Adjacent Areas, Canadian Society of Petroleum Geologists, Memoir 13, 1989, p. 600-608. **FREE**

CS ME 1989-2 Carbonate Buildups of the Gays River Formation, Lower Carboniferous Windsor Group, Nova Scotia, by R. C. Boehner, P. S. Giles, D. A. Murray and R. J. Ryan; *in* Reefs, Canada and Adjacent Areas, Canadian Society of Petroleum Geologists, Memoir 13, 1989, p. 609-621. **FREE**

CS ME 1989-1 Anatomy of a Telescoped Pull-Apart Basin: An Example from the Cambro-Ordovician Rocks in the Antigonish Highlands of Nova Scotia, by J. D. Keppie and J. B. Murphy; *in* Maritime Sediments and Atlantic Geology, v. 24, 1988, p. 123-138. **FREE**

CS ME 1988-8 Primary and Secondary Structural Features in the Eastern Portion of the South Mountain Batholith, Southwestern Nova Scotia: Implications for Regional Stress Orientations during Intrusion, by R. J. Horne, M. C. Corey, L. J. Ham and M. A. MacDonald; *in* Maritime Sediments and Atlantic Geology, v. 24, 1988, p. 71-82. **FREE**

CS ME 1988-7 Heavy Minerals and Sediment Dispersal Trends as Exploration Tools for Potential Tin and Gold Paleoplacers in Carboniferous Rocks, Nova Scotia, by R. J. Ryan, R. Turner, R. R. Stea and P. J. Rogers; *in* Prospecting in Areas of Glaciated Terrain, 1988, p. 41-56. **FREE**

CS ME 1988-6 Contributions on the Geology of Granitoid and Host Rocks, Meguma Terrane, Nova Scotia, edited by D. J. Kontak and S. M. Barr; a special issue of Maritime Sediments and Atlantic Geology, v. 24, no. 1, 1988, 121 pages. **$10.00**

CS ME 1988-5 The Provenance of Tills Overlying the Eastern Part of the South Mountain Batholith, Nova Scotia, by R. M. Graves and P. W. Finck; *in* Maritime Sediments and Atlantic Geology, v. 24, 1998, p. 61-70. **FREE**

CS ME 1988-4 Silurian-Permian Palaeocontinental Reconstructions and Circum-Atlantic Tectonics, by D. V. Kent and J. D. Keppie; *in* Caledonian-Appalachian Orogen, Geological Society Special Publication no. 38, 1988, p. 469-480. **FREE**

CS ME 1988-3 U-Pb and Rb-Sr Geochronology of the Wedgeport Granitoid Pluton, Southwestern Nova Scotia, by R. F. Cormier, J. D. Keppie and A. L. Odom; *in* Canadian Journal of Earth Sciences, v. 25, 1988, p. 255-261. **FREE**

CS ME 1988-2 Gypsum in Canada - Present Status and Future Developments, by J. H. Fowler and G. C. Adams; *in* Mining Engineering, February 1988, p. 120-124. **FREE**

CS ME 1988-1 Metasomatic Origin of Spessartine-Rich Garnet in the South Mountain Batholith, Nova Scotia, by D. Kontak and M. C. Corey; *in* Canadian Mineralogist, v. 26, 1988, p. 315-334. **FREE**

CS ME 1987-14 Dating Transcurrent Terrane Accretion: An Example from the Meguma and Avalon Composite Terranes in the Northern Appalachians, by J. D. Keppie and R. D. Dallmeyer; *in* Tectonics, v. 6, no. 6, December 1987, p. 831-847. **FREE**

CS ME 1987-13 Late Paleozoic Sedimentation and Basin Development Adjacent to the Cobequid Highlands Massif, Eastern Canada, by R. J. Ryan, J. H. Calder, H. V. Donohoe, Jr., and R. Naylor; *in* Sedimentary Basins and Basin Forming Mechanisms, edited by C. Beaumont and A. J. Tankard, Canadian Society of Petroleum Geologists, Memoir 12, 1987, p. 311-317. **FREE**

CS ME 1987-12 Catchment Basin Analysis Applied to Surficial Geochemical Data, Cobequid Highlands, Nova Scotia, by G. F. Bonham-Carter, P. J. Rogers and D. L. Ellwood; *in* Journal of Geochemical Exploration, v. 29, 1987, p. 259-278. **FREE**

CS ME 1987-11 Lithophile Elements and Exploration Using Centre-Lake Bottom Sediments from the East Kemptville Area, Southern Nova Scotia, Canada, by P. J. Rogers and R. G. Garrett; *in* Journal of Geochemical Exploration, v. 28, 1987, p. 467-478. **FREE**

CS ME 1987-10 Age of the Five Islands Formation, Nova Scotia, and the Deglaciation of the Bay of Fundy, by R. R. Stea and D. M. Wightman; *in* Quaternary Research, v. 27, 1987, p. 211-219. **FREE**

CS ME 1987-9 Polyphase Late Paleozoic Tectonothermal Evolution of the Southwestern Meguma Terrane, Nova Scotia: Evidence from $^{40}Ar/^{39}Ar$ Mineral Ages, by R. D. Dallmeyer and J. D. Keppie; *in* Canadian Journal of Earth Sciences, v. 24, 1987, p. 1242-1254. **FREE**

CS ME 1987-8 Development Potential for Offshore Placer and Aggregate Resources of Nova Scotia, Canada, by C. K. Miller and J. H. Fowler; *in* Marine Mining, v. 6, 1987, p. 121-139. **FREE**

CS ME 1987-7 Sedimentology, Structure, and Metallogeny of the Goldenville Formation, Meguma Terrane, Isaacs Harbour, Nova Scotia, by J. D. Keppie; *in* Geological Society of America Centennial Field Guide, Northeastern Section, 1987, p. 433-439. **FREE**

CS ME 1987-6 Anorthosites and Gabbroic Bodies in Northern Cape Breton Island, Nova Scotia, by C. Dupuy, J. Dostal, P. K. Smith and J. D. Keppie; *in* Maritime Sediments and Atlantic Geology, v. 22, no. 2, 1986, p. 136-147. **FREE**

CS ME 1987-4 Barytes, the "No-Wait" Agent, by J. H. Fowler; *in* CIM Bulletin, v. 79, 1987, no. 889, p. 38-42. **FREE**

CS ME 1987-3 Two Rb-Sr Whole Rock Isochrons from Plutons in the Cobequid Highlands, Nova Scotia, Canada, by H. V. Donohoe, A. N. Halliday and J. D. Keppie; *in* Maritime Sediments and Atlantic Geology, v. 22, 1986, p. 148-154. **FREE**

CS ME 1987-2 Fossil Myriapod Trails in the Permo-Carboniferous Strata of Northern Nova Scotia, Canada, by R. J. Ryan; *in* Maritime Sediments and Atlantic Geology, v. 22, 1986, p. 156-161. **FREE**

CS ME 1987-1 Rb-Sr Isotopic Data from Three Suites of Igneous Rocks, Cape Breton Island, Nova Scotia, by J. D. Keppie and A. N. Halliday; *in* Maritime Sediments and Atlantic Geology, v. 22, 1986, p. 162-171. **FREE**

CS ME 1986-4 Contributions to the Geology of the Meguma Terrane, Nova Scotia, ed. J. D. Keppie; a special issue of Maritime Sediments and Atlantic Geology, v. 22, no. 1, 1986, 135 pages. **$10.00**

CS ME 1986-3 Review of some Chemical and Mineralogical Characteristics of Granitoid Rocks Hosting Sn, W, U, Mo Deposits in Newfoundland and Nova Scotia, by A. K. Chatterjee and D. F. Strong; *in* High Heat Production (HHP) Granites, Hydrothermal Circulation and Ore Genesis, papers presented at the conference organized by The Institution of Mining and Metallurgy, St. Austell, Cornwall, England, September 22-25, 1985, p. 489-516. **FREE**

CS ME 1986-2 Upper Carboniferous Strata of the Tatamagouche Syncline, Cumberland Basin, Nova Scotia, by R. J. Ryan; *in* Current Research, Part B, Geological Survey of Canada, Paper 85-01B, p. 481-490, 1985. **FREE**

CS ME 1986-1 The Petrology, Geochemistry, and Economic Potential of the Musquodoboit Batholith, Nova Scotia, by M. A. MacDonald and D. B. Clarke; *in* Canadian Journal of Earth Sciences, v. 22, 1985, p. 1633-1642. **FREE**

CS ME 1985-3 Windsor Group Salt and Potash in Nova Scotia, Canada, by Robert C. Boehner; *in* Sixth International Symposium on Salt, v. 1, 1983, p. 99-113. **FREE**

CS ME 1985-2 Cambrian Volcanism in Nova Scotia, Canada, by J. B. Murphy, K. Cameron, J. Dostal, J. D. Keppie and A. J. Haynes; *in* Canadian Journal of Earth Sciences, v. 22, no. 4, 1985, p. 599-606. **FREE**

CS ME 1985-1 Rare-Earth and other Element Variations in Greisens and Granites Associated with East Kemptville Tin Deposit, Nova Scotia, Canada, by A. K. Chatterjee and D. F. Strong; *in* Transactions/Section B of the Institute of Mining and Metallurgy, v. 93, 1984, B59-B70. **FREE**

CS ME 1984-7 Stratigraphy and Depositional History of Marine Evaporites in the Windsor Group, Shubenacadie and Musquodoboit Structural Basin, Nova Scotia, Canada, by Robert C. Boehner; *in* Neuvième Congres International de Stratigraphie et de Geologie du Carbonifère, IX-ICC v. 3, 1984, p. 163-178. **FREE**

CS ME 1984-6 Discriminant and Factor Analysis of Geochemical Data from Granitoid Rocks Hosting the Millet Brook Uranium Mineralization, South Mountain Batholith, Nova Scotia, by A. K. Chatterjee and D. F. Strong; *in* Uranium, v. 1, 1984, p. 289-305. **FREE**

CS ME 1984-5 Mining in Nova Scotia - Past and Present, by H. V. Donohoe, Jr.; *in* CIM Directory 1984, p. 1-24. **FREE**

CS ME 1984-4 The Appalachian Collage, by J. D. Keppie; *in* The Caledonide Orogen - Scandinavia and Related Areas, eds. D. G. Gee and B. A. Sturt, 1985, p. 1217-1226. **FREE**

CS ME 1984-3 Petrology and Geochemistry of Devono-Carboniferous Volcanic Rocks in Nova Scotia, by J. Dostal, J. D. Keppie and C. Dupuy; *in* Maritime Sediments and Atlantic Geology, v. 19, 1983, p. 59-71. **FREE**

CS ME 1984-2 Times of Deformation in the Canadian Appalachians, by J. D. Keppie, P. St. Julien, C. Hubert, J. Beland, B. Skidmore, L. R. Fyffe, A. A. Ruitenberg, S. R. McCutcheon, H. Williams and J. Bursnall; *in* Regional Trends in the Geology of the Appalachian-Caledonian-Hercynian-Mauritanide Orogen, ed. P. E. Schenk, 1983, p. 307-313. **FREE**

CS ME 1984-1 Proceedings of the Deformation Study Group, Caledonide Orogen Project, by J. D. Keppie, D. G. Gee, D. Roberts, D. Powell, M. D. Max, P. Osberg, A. Pique, and J. P. LeCorche; *in* Regional Trends in the Geology of the Appalachian- Caledonian- Hercynian-Mauritanide Orogen, ed. P. E. Schenk, 1983, p. 275-278. **FREE**

CS ME 1983-2 Uranium and Thorium in Paleozoic Rhyolites of Nova Scotia, by J. Dostal, C. Dupuy, and J. D. Keppie; *in* Canadian Journal of Earth Sciences, v. 20, no. 2, 1983, p. 266-274. **FREE**

CS ME 1983-1 A Multivariate Approach to Geochemical Distinction Between Tin-Specialized and Uranium-Specialized Granites of Southern Nova Scotia, by A. K. Chatterjee, D. F. Strong, and G. K. Muecke; *in* Canadian

Journal of Earth Sciences, v. 20, 1983. **FREE**

CS ME 1982-5 The Distribution of Gold in Rocks and Minerals of the Meguma Group of Nova Scotia, Canada, by R. R. Brooks, A. K. Chatterjee, P. K. Smith, D. E. Ryan and H. F. Zhang; *in* Chemical Geology, v. 35, 1982; 9 pages. **FREE**

CS ME 1982-4 The Minas Geofracture, by J. D. Keppie, 1982; *in* Geological Association of Canada, Special Paper 24, 18 pages. **FREE**

CS ME 1982-3 Geochemistry and the Distribution of Uranium and Thorium in the Granitoid Rocks of the South Mountain Batholith, Nova Scotia, by A. K. Chatterjee and G. K. Muecke; *in* Uranium in Granites; Geological Survey of Canada, Paper 81-23, p. 11-17, 1982; 17 pages. **FREE**

CS ME 1982-2 A Rapid Method for the Determination of Gold and Silver in Sulfide Ores and Rocks, by R. R. Brooks, J. Holzbecher, D. E. Ryan, H. F. Zhang and A. K. Chatterjee, 1981; *in* Atomic Spectroscopy, v. 2, no. 5, 1981; 4 pages. **FREE**

CS ME 1982-1 Observations on the Ichnology of the Meguma Group (?Cambro-Ordovician) of Nova Scotia, by R. K. Pickerill and J. D. Keppie, 1981; *in* Maritime Sediments and Atlantic Geology, v. 17, 1981; 9 pages. **FREE**

CS ME 1981-2 Plate Tectonics and Tectonic Mapping, by J. Duncan Keppie, 1981; *in* Episodes, v. 1981, no. 4, 1981; 4 pages. **FREE**

CS ME 1981-1 Determination of Gold in Natural Waters at the Parts-Per-Trillion (pg cm^{-3}) Level, by R. R. Brooks, A. K. Chatterjee and D. E. Ryan; *in* Chemical Geology, 33, 1981; 7 pages. **FREE**

CS ME 1980-2 Granitoid and other Plutonic Rocks of Nova Scotia, by D. B. Clarke, S. M. Barr and H. V. Donohoe, 1980, 10 pages; *in* Proceedings: "The Caledonides in the U.S.A." I.G.C.P. Project 27: Caledonide Orogen. **FREE**

CS ME 1980-1 Paleozoic Volcanic Rocks of Nova Scotia, by J. D. Keppie and J. Dostal, 1980, 8 pages; *in* Proceedings: "The Caledonides in the U.S.A." I.G.C.P. Project 27: Caledonide Orogen. **FREE**

ECONOMIC GEOLOGY SERIES

Detailed scientific reports on mineral commodities of economic or potential economic interest.

EGS ME 1996-1 Building Stone in Nova Scotia, by G. B. Dickie, 1996, 165 pages. **$10.00 (Microfiche $3.00)**

EGS ME 1992-2 Aggregate Potential of Cumberland and Colchester Counties, Nova Scotia, by G. Prime, 1992, 172 pages. **$10.00 (Microfiche $3.00)**

EGS ME 1992-1 Various Industrial Mineral Commodities in Nova Scotia, by R. H. MacDonald, 1992, 99 pages. **$7.00 (Microfiche $2.00)**

EGS ME 1991-1 Gypsum and Anhydrite Resources in Nova Scotia, by G. C. Adams, 1991, 305 pages, 1 map, scale 1:500 000. **$25.00 (Microfiche $4.00)**

EGS ME 1990-3 Oil Shale Resources of Nova Scotia, by W. D. Smith and R. D. Naylor, 1990, 73 pages. **$12.00 (Microfiche $2.00)**

EGS ME 1990-2 Filler and Extender Minerals in Nova Scotia, by Peter Luke, 1990, 64 pages. **$6.00 (Microfiche $2.00)**

EGS ME 1990-1 Diatomaceous Earth Occurrences in Nova Scotia, by A. R. Anderson, 1990, 132 pages. **$15.00 (Microfiche $3.00)**

EGS ME 1989-1 Properties and Uses of Nova Scotia Clays and Shales, by Susan Gouthro, 1989, 288 pages. **$20.00 (Microfiche $3.00)**

EGS ME 1975-1 Iron Deposits of Nova Scotia, by J. D. Wright, 1975, 154 pages, 1 map. **$6.00**

EGS ME 1974-1 Geology and Trace Element Studies of Manganese Occurrences in Nova Scotia, by D. G. Bishop and J. D. Wright, 1974, 255 pages. **$7.50**

ILLUSTRATIONS

Geoscience diagrams other than maps.

!!!NEW!!!

Illustration ME 1998-3 Sydney Mines: Fossil Interpretation Project, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

!!!NEW!!! **Illustration ME 1998-2** Brule Fossil Site Project: Preserving and Developing a World Class Fossil Discovery in Nova Scotia, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

!!!NEW!!! **Illustration ME 1998-1** The Fossil Cliffs of Joggins: Towards World Heritage Site Designation, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

INFORMATION CIRCULARS

Free promotional pamphlets or booklets on various geoscience topics.

!!!NEW!!! **IC ME 59** Properties Available for Option in Nova Scotia, January 1999, a joint project between the Nova Scotia Department of Natural Resources, Minerals and Energy Branch, the Chamber of Mineral Resources of Nova Scotia and the Mining Society of Nova Scotia, 1999, 82 pages. **FREE**

IC ME 58 A Guide to Mineral Exploration Legislation in Nova Scotia, 1998, 8 pages. **FREE**

IC ME 57 Properties Available for Option in Nova Scotia, January 1998, a joint project between the Nova Scotia Department of Natural Resources, Minerals and Energy Branch, the Chamber of Mineral Resources of Nova Scotia and the Mining Society of Nova Scotia, 1998, 70 pages. **FREE**

IC ME 55 Safe Work Methods Handbook, by Minerals and Energy Branch, Nova Scotia Department of Natural Resources, August 1997, 40 pages. **FREE**

IC ME 53 Secondary Processing of Industrial Minerals in Nova Scotia, by Nova Scotia Department of Natural Resources, Minerals and Energy Branch, 1998, 28 pages. **FREE**

IC ME 52 Geology and Mineral Deposits of Nova Scotia, by H. V. Donohoe, Jr., 1996. **FREE**

IC ME 51 Gold Deposits in the Meguma Group of Nova Scotia, by P. K. Smith and D. J. Kontak, 1996. **FREE**

IC ME 50 Carbonate-Hosted Zn-Pb-Ba-Ag-Cu Deposits in the Lower Carboniferous of Nova Scotia: The Irish Connection, by D. J. Kontak, 1996. **FREE**

IC ME 49 Ni-Cu-Co Associated with Mafic and Ultramafic Rocks of Cape Breton Island, by G. J. DeMont, 1996. **FREE**

IC ME 48 Cretaceous Kaolin Clay and Silica Sand Deposits in Nova Scotia, by P. W. Finck and R. R. Stea, 1996. **FREE**

IC ME 47 Vein and Breccia Deposits of Fe-Cu-Co-Ni-Ba-Au Associated with the Cobequid-Chedabucto Fault Zone, Nova Scotia, by G. A. O'Reilly, 1996. **FREE**

IC ME 46 Copper Deposits in the Carboniferous Rocks of Northern Nova Scotia, by R. J. Ryan, 1996. **FREE**

IC ME 45 Take Advantage of Mineral Exploration and Development in Nova Scotia, by Nova Scotia Department of Natural Resources, 1996. **FREE**

IC ME 42 A Sign to Watch Your Step, by Mining Engineering Section, Nova Scotia Department of Natural Resources, July 1995. (This information brochure describes hazards associated with abandoned mine sites). **FREE**

IC ME 41 Career Choices in the Petroleum Industry, by Petroleum Resources Section, Nova Scotia Department of Natural Resources, September 1993, 7 pages. **FREE**

IC ME 39 Petroleum Resources Offshore and Onshore Nova Scotia, Canada, by Nova Scotia Department of Natural Resources, Petroleum Resources Section, 1994, 7 pages. **FREE**

IC ME 36 Metalliferous Environments of Nova Scotia: Base Metals, by James M. Patterson, 1993, 18 pages (this brochure summarizes Information Series ME 22.) **FREE**

IC ME 34 GEOFACTS: Industrial Minerals in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 33 GEOFACTS: Salt in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 32 GEOFACTS: Gypsum in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 31 GEOFACTS: Anhydrite in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 30 GEOFACTS Modelling the Development of Rifted Continental Margins - "Time Travel by Computer", by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 29 GEOFACTS: Canada's Dynamic Coastline, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 28 GEOFACTS: Hydrocarbon Charge Modelling, by Energy Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 27 GEOFACTS: Using Digital Sound in Marine Geoscience, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 26 The Cohasset Project, by Petroleum Resources Section, Nova Scotia Department of Natural Resources, revised March 1993, 10 pages. **FREE**

IC ME 25 One of the Greatest Treasures: The Geology and History of Coal in Nova Scotia, by J. H. Calder, K. S. Gillis, D. J. MacNeil, R. D. Naylor and N. Watkins-Campbell, 1993, 42 pages. **FREE**

IC ME 24 Industrial Minerals in Nova Scotia, by Nova Scotia Department of Natural Resources, Mineral Development Division, 1992, 25 pages. **FREE**

IC ME 23 Petroleum Resources Offshore and Onshore Nova Scotia, Canada, by Nova Scotia Department of Natural Resources, Petroleum Resources Section, 1991, 8 pages. **Out of Print**

IC ME 22 Land Use Policy Development Project, by David B. Hopper and Andrew J. Kendall, November 1988. **FREE**

IC ME 21 A Walking Tour of Rocks, Minerals, and Building Stones of Prince Street, Truro, by Jo-Anne Goodwin et al., August 1988. **FREE**

IC ME 20 Aggregates in Nova Scotia, by G. Prime, 1988, 3rd edition 1993. **Out of Print**

IC ME 19 Salt in Nova Scotia, by G. Prime, 1988, 3rd edition, 1993. **Out of Print**

IC ME 18 Peat Moss in Nova Scotia, by A. R. Anderson, 2nd edition, 1993. **Out of Print**

IC ME 16 Gypsum and Anhydrite in Nova Scotia, by G. C. Adams, 1988, 3rd edition 1993. **Out of Print**

IC ME 15 Barite, Celestite and Fluorite in Nova Scotia, by J. H. Fowler, 1988, 2nd edition 1991. **Out of Print**

IC ME 14 Silica in Nova Scotia, by R. H. MacDonald, 1988, 2nd edition 1991. **Out of Print**

IC ME 13 Limestone and Dolomite in Nova Scotia, by P. Luke and R. H. MacDonald, 1988, 3rd edition 1993. **Out of Print**

IC ME 12 Building Stone in Nova Scotia, by G. B. Dickie, 1988, 3rd edition 1993. **Out of Print**

IC ME 11 A Walking Tour of Rocks, Minerals, and Landforms of Victoria Park, Truro, by Howard Donohoe and Martha Devanney, 1987. **FREE**

IC ME 10 A Walking Tour of Rocks, Minerals and Building Stones along Spring Garden Road, Halifax, by Katherine Bishop, Anne Stevenson, Martha Devanney and Howard Donohoe, 1987. **FREE**

IC ME 9 A Walking Tour of Rocks, Minerals and Landforms of Peggy's Cove, by Anita Sampson and Howard Donohoe, 1987. **FREE**

IC ME 7 A Walking Tour of Rocks, Minerals and Landforms of Point Pleasant Park, by Nova Scotia Department of Mines and Energy, June 1986. **FREE**

IC ME 4 Nova Scotia Gold, by Nova Scotia Department of Mines and Energy, May 1986. **FREE**

IC ME 3 A Walking Tour of Rocks, Minerals, and Building Stones in Downtown Halifax, by Nova Scotia Department of Mines and Energy, April 1986. **FREE**

IC ME 2 Mineral Rights, Landowners, and Mineral Exploration, by Nova Scotia Department of Mines and Energy, February 1986. **FREE**

IC ME 1 Directory of Goods and Services for Exploration Companies, by Shyanne LeBlanc, Trecia Schell, and Howard V. Donohoe, Jr., revised February 1993. **FREE**

INFORMATION SERIES

Promotional booklets on various geoscience topics.

IS ME 24 Twentieth Annual Review of Activities, by Nova Scotia Department of Natural Resources, Minerals and Energy Branch, 1996, 27 pages. **FREE**

IS ME 23 Abandoned Mine Openings: Hazards and Remediation Handbook, by Mining Engineering Section, Nova Scotia Department of Natural Resources, July 1995, 90 pages. (This handbook is intended to provide private landowners with information regarding the potential hazards and legal liabilities of abandoned mine openings located on their property, and to describe remedial methods to reduce or eliminate the hazard). **FREE**

IS ME 22 Metalliferous Environments in Nova Scotia, by James M. Patterson, 1993, 59 pages. **$5.00**

IS ME 19 Nova Scotia Dimension Stone for Designers, Developers and Quarriers, 1989, 24 pages. **FREE**

IS ME 14 Reflection Seismic Coverage of Onshore and Nearshore Nova Scotia 1942-1987, compiled by P. G. McMahon, 1988, 34 pages, 3 maps in back pocket. **$5.00**

IS ME 13 Gold in Nova Scotia, by Jennifer Bates, 1987, 48 pages. **FREE**

IS ME 11 Surface Petroleum Shows, Onshore Nova Scotia, compiled by Gayle Short, March 1986, 33 pages. **Out of Print (Microfiche $1.00)**

IS ME 10 Petroleum Wells and Drillholes with Petroleum Significance, Onshore Nova Scotia, compiled by P. McMahon, G. Short, and D. Walker, January 1986, 194 pages. **Out of Print (Microfiche $2.00)**

MEMOIRS

Comprehensive, detailed scientific reports on the geology of specific areas.

Memoir ME 10 Geology of the Cumberland Basin, Cumberland, Colchester and Pictou Counties, Nova Scotia, by R. J. Ryan and R. C. Boehner, 1994, 222 pages, 155 text figures and back pocket containing 5 pocket figures, and 4 coloured geology maps: Map ME 1990-11, Map ME 1990-12, Map ME 1990-13 and Map ME 1990-14. **$69.00 (Microfiche $6.00)**

Memoir ME 9 Geology of the Loch Lomond Basin and Glengarry Half Graben, Richmond and Cape Breton Counties, Cape Breton Island, Nova Scotia, by R. C. Boehner and G. Prime, 1993, 68 pages and 1 map (includes Map ME 1985-2, Geology of the Loch Lomond Basin and Glengarry Half Graben, Nova Scotia, scale 1:50 000). **$8.00 (Microfiche $2.00)**

Memoir ME 8 Geology of the Antigonish Basin, Antigonish County, Nova Scotia, by R. C. Boehner and P. S. Giles, 1993, 132 pages. **$10.00 (Microfiche $3.00)**

Memoir ME 7 The Geology of the George River Series, Cape Breton, Stratigraphy, Structure and Economic Geology, by G. C. Milligan, 1970, 111 photocopied pages, plus 5 coloured and 2 black/white maps in back pocket. **$10.00. (Microfiche $3.00)**

Memoir ME 5 Pleistocene Geology of the Annapolis Valley, Nova Scotia, by C. F. Hickox, 1962, 36 pages, 1 map. **$2.00**

Memoir ME 4 The Older Paleozoic of Pictou County, Nova Scotia, by R. H. Maehl, 1961, 109 pages, 1 appendix, 1 map. **$3.00**

Memoir ME 3 The Stratigraphy of the Windsor Group in the Antigonish Quadrangles and the Mahone Bay - St. Margaret's Bay Area, Nova Scotia, by Nathaniel McLean Sage, Jr., 1954, 168 pages. **Out of Print (Microfiche only $2.00)**

Memoir ME 2 Stratigraphy and Paleontology of the Windsor Group (Upper Mississippian) in parts of Cape Breton Island, Nova Scotia, by Maurice C. Stacy, 1953, 143 pages. **Out of Print (Microfiche only $3.00)**

Memoir ME 1 Gypsum and Anhydrite in Nova Scotia, by N. R. Goodman, 1952, 75 pages. **Out of Print (Microfiche only $2.00)**

MISCELLANEOUS PUBLICATIONS

Older reports on various geoscience topics that were originally published without a series title.

MP ME 1975-4 Bibliography of the Geology of Nova Scotia, by D. J. Gregory, 1975, 237 pages. **Out of Print (Microfiche only $4.00)**

MP ME 1975-3 Core Drilling in Nova Scotia with Government Drills, 1967-1971, 49 pages. **$1.00**

MP ME 1975-2 Drilling Logs of Government Core Drills, 1973, by I. MacDougall and D. W. Grimm, 76 pages. **$1.00**

MP ME 1975-1 Drilling Logs of Government Core Drills, 1972, by I. MacDougall and D. W. Grimm, 85 pages. **$1.00**

NOTE: Drilling logs after 1973 are published as part of the Report Series; e.g. Drilling Logs for 1974 are in Report ME 1976-1.

MP ME 1972-4 Geology of the Middle River and Baddeck Forks Map Areas, Victoria County, Nova Scotia, by B. E. Jones and T. G. N Covert, 1972, 124 pages and 5 maps. **$5.00**

MP ME 1972-3 Clay and Sand Deposit at Elmsvale, Halifax County, Nova Scotia, by J. H. Fowler, 1972, 62 pages and drillhole sections. **Out of Print (Microfiche Only $2.00)**

MP ME 1972-1 Drilling Logs of Government Core Drills, 1971, by C. F. Townsend and D. W. Grimm, 81 pages. **$1.00**

MP ME 1971-1 Drilling Logs of Government Core Drills, 1970, by C. F. Townsend and D. W. Grimm, 71 pages. **$1.00**

MP ME 1970-1 Drilling Logs of Government Core Drills, 1969, by C. F. Townsend and D. W. Grimm, 65 pages. **$1.00**

MP ME 1969-2 Handbook for Companies Planning Offshore Drilling by Nova Scotia Department of Mines, 1969, 23 pages. **$0.50**

MP ME 1969-1 Drilling Logs of Government Core Drills, 1968 by C. F. Townsend and D. W. Grimm, 58 pages. **$1.00**

MP ME 1968-2 Core Drilling in Nova Scotia with Government Drills, 1871-1966, 176 pages. **$2.00**

MP ME 1968-1 Drilling Logs of Government Core Drills, 1967, by C. F. Townsend and D. W. Grimm, 39 pages. **$1.00**

MP ME 1967-1 Drilling Logs of Government Core Drills, 1966, by C. F. Townsend and D. W. Grimm, 27 pages. **$1.00**

MP ME 1966-3 Metallic Mineral Occurrences Recorded in the Province of Nova Scotia, by Nova Scotia Department of Mines, 1966, 350 pages. **$4.00**

MP ME 1966-1 Drilling Logs of Government Core Drills, 1965, by C. F. Townsend and D. W. Grimm, 55 pages. **$1.00**

MP ME 1965-1 Drilling Logs of Government Core Drills, 1964, by C. F. Townsend and D. W. Grimm, 43 pages. **$1.00**

MP ME 1964-1 Drilling Logs of Government Core Drills, 1963, by C. F. Townsend and D. W. Grimm, 36 pages. **$1.00**

MP ME 1963-1 Drilling Logs of Government Core Drills, 1962, by C. F. Townsend and D. M. MacLeod, 35 pages. **$1.00**

MP ME 1962-1 Drilling Logs of Government Core Drills, 1961, by C. F. Townsend and D. M. MacLeod, 49 pages. **$1.00**

MP ME 1961-1 Drilling Logs of Government Core Drills, 1960, by C. F. Townsend and D. M. MacLeod, 33 pages. **$1.00**

MP ME 1960-1 Drilling Logs of Government Core Drills, 1959, by M. G. Goudge and D. M. MacLeod, 38 pages. **$1.00**

MP ME 1959-1 Drilling Logs of Government Core Drills, 1958, by M. G. Goudge and D. M. MacLeod, 34 pages. **$1.00**

MP ME 1958-2 Possibilities for Occurrence of Petroleum Reservoirs in Nova Scotia, by W. A. Bell, 1958, 177 pages. **$1.00**

NOTE: Drilling Logs prior to 1958 are in Nova Scotia Department of Mines Annual Reports.

NEWSLETTERS

A quarterly newsletter entitled "Nova Scotia Minerals Update" highlighting topical Minerals and Energy Branch and mineral industry news, events, activities and personnel.

Minerals Update, Volume 15, No. 2, Spring 1998. **FREE**

OPEN FILE ILLUSTRATIONS

Unpublished geoscience diagrams other than maps.

!!!NEW!!!

OFI ME 1998-2 What's New, Exploration and Development Highlights, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster. **$2.00**

!!!NEW!!!

OFI ME 1998-1 Industrial Minerals, Natural Gas Production in 1998 - New Opportunities, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster. **$2.00**

OFI ME 1990-4 Detailed Drillhole Correlation, Tatamagouche Area (11E/14), Cumberland Basin, by R. J. Ryan, 1990, scale 1:1538. **$2.00**

OFI ME 1990-3 Detailed Drillhole Correlation, Oxford Area (11E/12), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:1177. **$2.00**

OFI ME 1990-2 Stratigraphic Section of the French River - River John Area (11E/11, 11E/14), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:1333. **$2.00**

OFI ME 1990-1 Stratigraphic Section of the Joggins Area (21H/09), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:2400. **$2.00**

OPEN FILE REPORTS

Unpublished reports on various geoscience topics.

OFR ME 1998-5 Classic Carboniferous Sections of the Minas and Cumberland Basins in Nova Scotia: with Special Reference to Organic Deposits, by J. H. Calder, R. C. Boehner, D. E. Brown, M. R. Gibling, P. K. Mukhopadhyay, R. J. Ryan and D. M. Skilliter; The Society for Organic Petrology, Annual Meeting Field Trip Guide Book, 29-30 July, 1998, 86 pages. **$10.00**

OFR ME 1998-4 Petroleum Occurrence in Drillholes from the Pictou Coalfield, by K. S. Gillis, 1998, 17 pages, 1 fold out coloured map. **$7.00**

OFR ME 1998-3 Author Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports, Contribution Series, Digital Geoscience Data Products, Open Files and Publications, 1996 and 1997, by Paul D. McCulloch, Sandra Marshall, Norman A. Lyttle and J. Susan Saunders, 72 pages. **$7.00**

OFR ME 1998-2 NTS Location Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports, Contribution Series, Digital Geoscience Data Products, Open Files and Publications, 1996 and 1997, by Paul D. McCulloch, Sandra Marshall, Norman A. Lyttle and J. Susan Saunders, 51 pages. **$5.00**

OFR ME 1998-1 Minerals and Energy Branch, Nova Scotia Department of Natural Resources, Province of Nova Scotia: An Organization Review, by C. G. Miller, Industry Government Relations Group, 1998, 60 pages. **$5.00**

OFR ME 1997-8 First Annual Nova Scotia Department of Natural Resources/Geological Survey of Canada (Atlantic) Joint Work Plan for Geoscience in Nova Scotia, 1997-1998, by H. Scott Swinden, Nova Scotia Department of Natural Resources, and J. Verhoef, Geological Survey of Canada (Atlantic), 15 pages. (Also available as Geological Survey of Canada Open File 3527). **$2.00**

OFR ME 1997-7 Report on the Diamond Drilling and Geological Investigations of the Steves Road Lead-Gold Occurrence, North Beaverbank, Hants County, Nova Scotia, by R. J. Ryan, 1997, 67 pages, 2 enclosures. **$10.00**

OFR ME 1997-6 Report on a Diamond-Drilling Program, Mile 16 East Road and MacKenzie Road South, Victoria County, Nova Scotia, by G. J. DeMont, 1997, 33 pages, 1 coloured figure. **$5.00**

OFR ME 1997-5 Report on a Diamond-Drilling Program in the North Brook Area, Victoria County, Nova Scotia, by G. J. DeMont, 1997, 17 pages. **$3.00**

OFR ME 1997-4 Core Logs of Drillholes MER-95-1 and MER-95-2, Piedmont and Merigomish Island, Pictou County, Nova Scotia, by K. S. Gillis, 1997, 17 p. **$3.00**

OFR ME 1997-3 Physical and Chemical Analyses of Kaolin from the Musquodoboit Valley, Nova Scotia, Canada, by Minerex Laboratories, Inc., and Industrial Minerals Services, Inc., 1997, 53 p. **$10.00**

OFR ME 1997-1 Late Quaternary Glaciation and Sea-Level Change Along the Atlantic Coast of Nova Scotia, by R. R. Stea, 1995, 219 pages, 2 maps in pocket, (scale 1:50 000 and Map ME 1992-1 scale 1:500 000). This open file report is a reformatted copy of a thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at Dalhousie University, 1995. **$30.00**

OFR ME 1996-11 Evaluation of 17 Kaolin Samples from the Musquodoboit and Shubenacadie Valleys, Nova Scotia, by S. E. Valji, Minerex Laboratories, Inc., Milledgeville, Georgia, for Nova Scotia Department of Natural Resources, 1996, 13 pages, 11 black and white figures. **$5.00**

OFR ME 1996-9 Mineral Potential Assessment Procedures Using GIS and Expert Modelling Approach, by J. Wang, 1996, 51 pages (6 coloured). **$25.00**

OFR ME 1996-8 Investigation of Epithermal-Type, Breccia-Hosted Pb-Zn-Ba-Au Mineralization Within the Tobeatic Shear Zone of Southwestern Nova Scotia, by M. C. Corey and R. M. Graves, 1996, 81 pages (11 coloured), 2 coloured figures in pocket. **$25.00**

OFR ME 1996-6 Diamond-Drill Core Log of Nova Scotia Department of Natural Resources Drillhole WBK 93-1, Whitten Brook, Walton Woods Road, Hants County, Nova Scotia, by R. C. Boehner, 1996, 9 pages. **$3.00**

OFR ME 1996-5 Geology of the Foord Seam and Associated Strata in the Area of the Stellarton Pit Mine, Pictou Coalfield, Stellarton Basin, Nova Scotia, by K. S. Gillis, R. D. Naylor and J. W. F. Waldron, 1996, 23 pages, 1 geology Map, scale 1:5000, 3 figures (one coloured). **$15.00**

OFR ME 1996-3 Cretaceous-Aged Kaolin Clays and Silica Sands in the Shubenacadie and Musquodoboit Valleys, Nova Scotia, Canada, by R. R. Stea, P. W. Finck, S. Pullan and M. C. Corey, 1996, 25 pages, 8 maps. **$17.00**

OFR ME 1996-2 Geology of the Cambridge Cove/Bramber and Red Head Map Areas 21H/01-Z1, Z3 and 21H/01-Y2, by Dr. R. G. Moore, 1996, 30 pages plus 2 geology maps, scale 1:10 000, in back pocket. **$10.00**

OFR ME 1996-1 Zeolite Mineral Assemblages in the North Mountain Basalt, Nova Scotia, by G. Pe-Piper and D. Horton, 1996, 30 pages plus 1 colour location map, scale 1:175 000, in back pocket. **$8.00**

OFR ME 1995-6 New Discoveries of Silica Sand and Kaolinite near Brierly Brook, Antigonish County, Nova Scotia, by R. R. Stea, P. W. Finck, G. Prime and G. J. DeMont; 1995, 5 pages. **$2.00**

OFR ME 1995-5 Reprocessing of Nova Scotia Gravity Data from the NSRF Gravity Database (1952-1988), for Mineral Resources Division, Nova Scotia Department of Natural Resources, by K. Howells and E. D. Clarke; 1995, 211 pages plus 1 map and 4 discs of gravity data. **$45.00**

OFR ME 1995-3 A Compilation of Geological, Surficial, Geochemical and Geophysical Data along the Tobeatic Shear Zone in the Little Tobeatic Lake and Peter Lake Areas of Southwestern Nova Scotia, by R. M. Graves, 1995, 42 pages with 14 figures (9 coloured) and 2 maps (1:25 000). **$15.00**

OFR ME 1995-2 Selected Metallic Mineral Occurrences of Cape Breton Island on NTS Map Sheets 11F/09, 11F/10, 11F/15, 11F/16, 11K/01 and 11K/02, Nova Scotia, by G. J. DeMont, 1995, 175 pages. **$15.00**

OFR ME 1995-1 Diamond-Drilling of Rare Element Pegmatites in Southwestern Nova Scotia, by M. C. Corey, 1995, 33 pages with 10 figures. **$5.00**

OFR ME 1994-26 Preliminary Results of Drilling Quaternary and Cretaceous Sediments near Shubenacadie, Hants County, Nova Scotia, by P. W. Finck, R. R. Stea and D. F. Dwyer, 1994, 35 pages. **$4.00**

OFR ME 1994-23 Gold Mineralization in the Cape Breton Highlands, Nova Scotia, by P. K. Smith and G. A. O'Reilly, 1994, 16 pages. **$3.00**

OFR ME 1994-22 Geology of the Walton-Rainy Cove Brook Map-Area (NTS 21H/01-Z2 and Z4), Hants County, Nova Scotia, by R. G. Moore, 1994, 36 pages, plus 1 geological map, scale 1:10 000. **$6.00**

OFR ME 1994-21 Compilation of Seabright Resources Inc. Till and Soil Geochemical Data, Nova Scotia, by K. K. Woodman, R. R. Duncan, R. M. Graves, A. B. Hudgins and P. J. Rogers, 1994, 239 pages and 21 sample location maps, scale 1:50 000. **$50.00**

OFR ME 1994-20 Report on U-Pb Geochronology of Avalonian Rocks in Nova Scotia, by Donald W. Davis, 1994, 13 pages. **$3.00**

OFR ME 1994-16 Doughboy Point Drilling Program, Doughboy Point, Guysborough County, Nova Scotia, by R. H. MacDonald, 1994, 39 pages. **$4.00**

OFR ME 1994-15 Magnetic Signature of the Goldenville-Halifax Transition Zone: North Beaverbank, by M. S. King, 1994, 9 pages. **$3.00**

OFR ME 1994-13 Diamond-Drilling of the East Lake Tungsten Occurrence, Halifax County, Nova Scotia (NTS Sheet 11D/15), by M. C. Corey, 1994, 30 pages. **$5.00**

OFR ME 1994-12 Maximizing Investment by Timely Application of Desktop Digital Technology to Mineral Exploration: An Example from Nova Scotia, Canada, by P. J. Rogers, W. P. Jones and L. M. MacKenzie, 1994, 3 pages, includes 1 coloured figure. **$3.00**

OFR ME 1994-11 Recent Gold Discoveries on Cape Breton Island, Nova Scotia, by G. J. DeMont, 1994, 3 pages. **$1.00**

OFR ME 1994-10 Keyword Index to Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 14 pages of microfiche. **$3.00 (Microfiche only)**

OFR ME 1994-9 Author Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches, Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 250 pages. **$20.00**

OFR ME 1994-8 NTS Location Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches, Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 175 pages. **$15.00**

OFR ME 1994-5 Report on Geological Mapping, Mineral Inventory Studies and Diamond-Drilling Surveys at the Rifle Range and Krumrine Quarries, Upper Leitches Creek, Cape Breton County, Nova Scotia, by G. J. DeMont, 1994, 35 pages, 1 map. **$5.00**

OFR ME 1994-4 Magnetic Mineralogy and Susceptibility of the North-Central Meguma Group: Implications for the Interpretation of Aeromagnetic Total Field, First Derivative and Second Derivative, by M. S. King, 1994, 41 pages; includes 7 coloured figures. **$5.00**

OFR ME 1994-3 Multi-Media Geochemical Survey of the Dominique (Sn, Zn, Cu) Deposit, (NTS 20O/16), Yarmouth County, Nova Scotia, by P. A. Lombard and F. J. Boner, 1994, 170 pages. **$15.00**

OFR ME 1993-32 The Economic Impact of the Mineral Industry in Nova Scotia, prepared for Energy, Mines and Resources Canada, by Gardner Pinfold Consulting Economists Limited, August 1993, 74 pages. **$7.00**

OFR ME 1993-29 Selected Metallic Mineral Occurrences of Cape Breton Island, Nova Scotia on NTS Map Sheets 11F/09, 11F/10, 11F/15, 11F/16, 11K/01, by G. J. DeMont, 1993, 296 pages. **$15.00**

OFR ME 1992-20 Gold Potential in the Meguma Terrane: New Discoveries Combining Vertical Gradient Aeromagnetics, Biogeochemistry and Till Sampling, (NTS 21A/02 and 11E/08), by Paul K. Smith, Peter J. Rogers, Lyndon Jensen and Colin E. Dunn, 1992, 6 pages plus 7 figures. **$2.00**

OFR ME 1992-16 Multi-Media Detailed Geochemical Study of the Brazil Lake Pegmatites (NTS 20P/13), Yarmouth County, Nova Scotia, by M. A. MacDonald, F. J. Boner and P. A. Lombard, 1992, 159 pages. **$15.00**

OFR ME 1992-14 Preliminary Report on Geological, Geochemical, Fluid Inclusion and Isotope Studies of the Gays River Pb/Zn Deposit, Nova Scotia (11E/03B), by Dan Kontak, 1992, 220 pages, includes coloured plates. **$25.00**

OFR ME 1992-10 Selected Metallic Mineral Occurrences of Cape Breton Island, Nova Scotia (NTS 11F/14, 11F/15, 11F/16, 11K/02, 11K/03, 11K/06, 11K/07, 11K/10, 11K/15, 11K/16), by Garth J. DeMont, 1992, 290 pages. **$20.00**

OFR ME 1992-9 Mineralogical Investigations along the Upper Seal Harbour Anticline, Goldboro, Nova Scotia (11F/04D), by M. C. Corey, 1992, 77 pages, includes coloured plates. **$20.00**

OFR ME 1992-8 Geological and Geochemical Observations within the Tangier Gold Deposit (11D/15C), by M. C. Corey and R. F. Mills, 1992, 138 pages. **$15.00**

OFR ME 1992-7 An Evaluation of Debris Avalanches in the Cape Breton Highlands, Nova Scotia, (11K/07 and part of 11K/10), by P. W. Finck, 1992, 68 pages. **$5.00**

OFR ME 1992-3 Multi-Media Detailed Geochemical Study of the Canfield Creek Cu-Ag Deposit, North-Central Nova Scotia, by M. A. MacDonald, 1992, 90 pages. **$9.00**

OFR ME 1991-18 Multi-Media Detailed Geochemical Study of the Yava Lead Deposit - East Zone, by M. A. MacDonald, F. J. Boner and P. A. Lombard, 1991, 162 pages. **$16.00**

OFR ME 1991-16 Selected Mineral Occurrences of the Cumberland and Stellarton Basins and their Metallogenetic Implications, by R. J. Ryan, 1991, 197 pages. **$15.00**

OFR ME 1991-11 Index Maps and Map Data Sheets to Nova Scotia Department of Mines and Energy and Geological Survey of Canada Published and Open File Geochemical Maps of Nova Scotia (compiled to August 1991), by P. L. LeBlanc, N. A. Lyttle, J. M. Freeman, 1991, 165 pages, 2 maps. **$6.00 Maps only; $22.00 complete**

OFR ME 1991-10 Index Map and Map Data Sheets to Published Geological Survey of Canada Coloured Total Field and Vertical Gradient Aeromagnetic Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 50 pages plus 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-15). **$2.00 Map only; $7.00 complete**

OFR ME 1991-9 Index Map and Map Data Sheets to Published Nova Scotia Department of Mines and Energy and Geological Survey of Canada Surficial Geology Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 36 pages plus 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-14). **$2.00 Map only; $5.50 complete**

OFR ME 1991-8 Index Map and Map Data Sheets to Published Nova Scotia Department of Mines and Energy Bedrock Geology Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 64 pages plus 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-11). **$2.00 Map only; $8.00 complete**

OFR ME 1991-7 Index Maps and Map Data Sheets to Published Geological Survey of Canada Bedrock Geology Maps of Nova Scotia (excluding Faribault - Fletcher Series), (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 129 pages plus 2 maps, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-12). **$4.00 Maps only; $17.00 complete**

OFR ME 1991-3 Diamond-Drilling of the Big Indian Lake Polyphase Intrusive Suite, Halifax County, Nova Scotia (NTS Map 11D/13), by Michael C. Corey, 1991, 35 pages. **$4.00**

OFR ME 1991-2 Selected Metallic Mineral Occurrences of Cape Breton Island on NTS Map Sheets 11F/14, 11K/01, 11K/02, 11K/06, 11K/07, by Garth DeMont, 1991, 200 pages. **$15.00**

OFR ME 1990-20 1988 Glencoe Drilling Program, Inverness County, by R. H. MacDonald, 1990, 18 pages. **$4.00**

OFR ME 1990-24 A Study of Pits and Quarries Rehabilitation, prepared for Energy, Mines and Resources Canada, Mineral Policy Sector, by Gardner Pinfold Consulting Economists Limited in association with Robert Parker Associates Limited, Peter Klynstra Landscape Architects Limited, 1990, 146 pages. **$10.00**

OFR ME 1990-23 Selected Bibliography of the Geology (Including Economic Geology) of Carboniferous Basins in Nova Scotia, compiled by R. C. Boehner, 1990, 33 pages. **$3.00**

OFR ME 1990-22 Gypsum in the Murchyville Area (11D/14D), Halifax County, Nova Scotia, by G. C. Adams, 1990, 51 pages, 3 maps. **$10.00**

OFR ME 1990-19 Summary of the Major Limestone - Dolomite Deposits of Nova Scotia, by R. H. MacDonald, 1990, revised edition of Nova Scotia Department of Mines and Energy Open File Report ME 1986-64. **$3.00**

OFR ME 1990-17 Regional Geochemical Surveys Conducted by the Nova Scotia Department of Mines and Energy from 1957 to 1989, by P. J. Rogers and P. A. Lombard, 1991, 53 pages, 23 figures and 3 tables. **$10.00**

OFR ME 1990-16 Index Maps and Map Data Sheets to Published Geological Survey of Canada Redline Total Field and Vertical Gradient Aeromagnetic Maps of Nova Scotia (compiled to August 1990), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1990, 97 pages plus 2 maps, scale 1" to 16 miles (1:1 013 760). **$4.00 Maps only; $14.00 complete**

OFR ME 1990-13 Index Map and Map Data Sheets to Published Geological Survey of Canada Faribault - Fletcher Bedrock Geology Maps of Nova Scotia (compiled to August 1990), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1990, 123 pages plus 1 map, scale 1" to 16 miles (1:1 013 760). **$2.00 Map only; $16.00 complete**

OFR ME 1990-9 Investigation of the Chegoggin Point, Lake George, Yarmouth County (200/16), Silica and Garnet Deposit, by R. H. MacDonald, 1990, 74 pages. **$4.00**

OFR ME 1990-8 Quaternary Geology of Nova Scotia, compiled by R. R. Stea and R. J. Mott; Guidebook for 53rd Annual Friends of the Pleistocene Field Excursion, May 25-28, 1990, 85 pages, 61 figures. **$11.00**

OFR ME 1990-7 Lithogeochemistry of the Western Portion of the South Mountain Batholith, Nova Scotia (21A/03, 21A/04, 21A/05, 21A/06, 21A/11, 21A/12, 21A/14), by L. J. Ham, M. C. Corey, R. J. Horne and M. A. MacDonald, 1990, 30 pages and 3 maps, scale 1:150 000 and 1:250 000. **$7.00**

OFR ME 1990-6 Trace Element Analysis of Till (-230 Mesh), South Mountain Batholith, (11D/05, 11D/12, 11D/13, 20P/13, 21A/03, 21A/04, 21A/05, 21A/06, 21A/07, 21A/09, 21A/10, 21A/11, 21A/12, 21A/14, 21A/15, 21A/16, 21H/02), by F. J. Boner, P. W. Finck and R. M. Graves, 1990, 40 pages, 1 map, scale 1:250 000. **$6.00**

OFR ME 1990-5 Heavy Mineral Till Geochemistry (Tin) of the Western South Mountain Batholith, by P. W. Finck, F. J. Boner and R. M. Graves, 1990, 40 pages, 3 maps. **$12.00**

OFR ME 1990-4 Heavy Mineral Till Geochemistry (Tin) of the Eastern and Central South Mountain Batholith, by P. W. Finck, F. J. Boner and R. M. Graves, 1990, 21 pages, 3 maps, scale 1:250 000. **$10.00**

OFR ME 1989-7 Geochemical Analyses of Bulk Stream Sediment Samples from Northern Nova Scotia, by R. F. Mills, 1989, includes many tables and 3 sample location maps, scale 1:250 000. **$40.00**

OFR ME 1989-6 Summary Report on Quarry Stone Used in the Construction of Dominion Building, Halifax, N. S., by G. B. Dickie, 1989, 16 pages. **$3.00**

OFR ME 1989-5 Open File Report on Selected Mineral Occurrences of the Cobequid Area, Nova Scotia, (NTS 11E/05, 11E/06, 11E/10, 11E/11, 11E/12, 21H/07, 21H/08), by K. E. Northcote, G. DeMont and A. Armitage, March 1989, 189 pages plus many tables. **$15.00**

OFR ME 1989-4 Open File Report on Selected Mineral Occurrences of Southern Cape Breton Island, Nova Scotia, (NTS 11F/10, 11F/15, 11F/16, 11K/01, 11K/02), by K. E. Northcote, G. DeMont and A. Armitage, March 1989, 94 pages plus tables. **$10.00**

OFR ME 1989-3 Open File Report on Selected Mineral Occurrences of the Antigonish Area, (NTS 11E/08, 11E/09 and 11E/16), by K. E. Northcote, G. DeMont and A. Armitage, February 1989, 184 pages plus tables. **$15.00**

OFR ME 1989-1 Lithogeochemistry of the Eastern Portion of the South Mountain Batholith, Nova Scotia, (Map Sheets 11D/05, 11D/12, 11D/13, 21A/09, 21A/10, 21A/15, 21A/16, and parts of 21H/01 and 21H/02), by L. J. Ham, S. W. Marsh, M. C. Corey, R. J. Horne and M. A. MacDonald, 62 pages, 2 maps. **$15.00**

OFR ME 1988-63 An Assessment of the Hydrocarbon and Compressed Air Storage Potential of Nova Scotia: A Summary, by Nolan, Davis and Associates Ltd., 1988, 22 pages. **$3.00**

OFR ME 1988-59 Interpretation of Till Geochemical Data in Nova Scotia, Canada, Using Mapped Till Units, Multi-Element Anomaly Patterns, and the Relationship of Till Clast Geology to Matrix Geochemistry, by R. G. Turner and R. R. Stea, 1988, 39 pages. **$5.00**

OFR ME 1988-57 Gypsum - Anhydrite Potential, Meadows Road Area, Cape Breton County, by G. Adams, 1988, 29 pages. **$5.00**

OFR ME 1988-56 An Assessment of the Hydrocarbon and Compressed Air Storage Potential of Nova Scotia Salt Deposits, by Nolan, Davis and Associates Ltd., 1988, 195 pages. **$20.00**

OFR ME 1988-55 Multi-Element Ratings Maps for Meguma Zone Lake Sediments, by P. J. Rogers, 1989, 34 pages, 3 maps. **$5.00**

OFR ME 1988-40 Aggregate Market Study for New Brunswick and Nova Scotia, by ADI Limited, 1988, Prepared for Mineral Policy Sector, Energy, Mines and Resources Canada, 309 pages. **$17.00**

OFR ME 1988-39 Marine Transport Study for Nova Scotia, by Leslie MacIntyre Maritime Associates Inc., May 1988, Prepared for Mineral Policy Sector, Energy, Mines and Resources Canada, 38 pages. **$5.00**

OFR ME 1988-13 A Study of U. S. East Coast Industrial Mineral Markets for New Brunswick, Newfoundland and Nova Scotia, by Metals Economics Group, 1988, Prepared for Mineral Policy Sector, Energy Mines and Resources Canada, 286 pages. **$15.00**

OFR ME 1988-11 Geochemical Investigations in the Rushmere - Moosefly Lakes Area, Yarmouth County, Nova Scotia (NTS 21A/04A), by R. F. Mills, 1988, 23 pages. **$3.00**

OFR ME 1987-32 Sulphur in Nova Scotia: Pugwash and Hilden Occurrences, by D. C. Carter, R. C. Boehner and G. C. Adams, 1987, 7 pages. **$5.00**

OFR ME 1987-27 Potential Crushed Stone Deposits on Tidewater in Nova Scotia, by G. B. Dickie, 1987, 15 pages. **$5.00**

OFR ME 1987-23 Report on the English Property (McKeen Quarry), Pictou County, by G. B. Dickie, 1987, 12 pages. **$5.00**

OFR ME 1987-5 Report on the Potential Stone Quarry, MacKenzie Farm, Hardwood Hill, Pictou County, Nova Scotia, by G. Dickie, 1986, 37 pages. **$5.00**

OFR ME 1987-2 Market Analysis for New Brunswick, Nova Scotia and Newfoundland Dimension Stone, by the DPA Group Incorporated in association with Jacques Whitford and Associates Limited, March 1987, 66 pages. **$10.00**

OFR ME 1986-54 The U.K. Experience on the Effects of Offshore Sand and Gravel Extraction on Coastal Erosion and the Fishing Industry, by R. Warren Drinnan and Douglas G. Bliss, Dobrocky Sea Tech Limited, August 1986, 90 pages. **$10.00**

OFR ME 1986-39 Agricultural Gypsum Project, by Peter Luke, 1986, 9 pages. **$3.00**

OFR ME 1986-25 The Gypsum Industry in Nova Scotia - Present Status and Future Prospects, by R. E. Wright and J. H. Brown; prepared for Nova Scotia Department of Mines and Energy by Centre for Resource Studies, Queen's University, 1985, 125 pages. **$15.00**

OFR ME 1986-21 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), 235 pages. **$10.00**

OFR ME 1986-20 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11K, 11N), 355 pages. **$10.00**

OFR ME 1986-19 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Central Nova Scotia (Map Sheets 11D, 11E), 280 pages. **$10.00**

OFR ME 1986-13 Study of Markets for Silica and Silica Sands Accessible from Nova Scotia and New Brunswick, by ADI Limited, 244 pages. **$10.00**

OFR ME 1986-12 A Study of Industrial Minerals Used in Oil and Gas Exploration on the Eastern Canadian Offshore, by Jacques, Whitford and Associates, and Cleland, Dunsmuir Consulting Limited, 231 pages. **$17.00**

OFR ME 1986-10 Study of Markets for Aggregate Materials Accessible from Nova Scotia and New Brunswick, by ADI Limited, March 1986, 398 pages. **$10.00**

NOTE: As of January 1986, all new Open File Reports have a report number assigned based upon the year of publication.

OFR ME 656 The Development Potential for Nova Scotia's Offshore Aggregate and Placer Resources, by John Fowler and Craig Miller, 1985, 69 pages. **$10.00**

OFR ME 651 Gypsum Property, Ownership and Leases, by Mark W. G. King, 1985, 140 pages. **$10.00**

OFR ME 650 Guide to the Granites and Mineral Deposits of Southwestern Nova Scotia, edited by A. K. Chatterjee and D. B. Clarke, 1985, 264 pages. **$15.00**

OFR ME 648 Current Market Economics of the Strontium Minerals by Metals Economic Group of Halifax, Nova Scotia, and Boulder, Colorado, 1985, 54 pages. **$5.00**

OFR ME 621 Effects of Location on Mine Development Potential: Nova Scotia's Competitive Position in Canada, by D. W. Davis, B. W. MacKenzie and M. L. Bilodeau, 1985, 103 pages. **$15.00**

OFR ME 608 Industrial Mineral Occurrences Map and Data Compilation, Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 21 pages, 1 map. **$4.00**

OFR ME 607 Industrial Mineral Occurrences Map and Data Compilation, Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11N), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 29 pages, 1 map. **$4.00**

OFR ME 606 Industrial Mineral Occurrences Map and Data Compilation, Central Nova Scotia (Map Sheets 11D, 11E), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 22 pages, 1 map. **$4.00**

OFR ME 605 Regional Lake Sediment Survey of the Meguma Zone, Southern Nova Scotia: New Analytical Data, by P. J. Rogers, M. A. MacDonald and D. W. Rigby, 1985, 65 pages, 2 maps. **$5.00**

OFR ME 603 Preliminary Feasibility Study for an Underground Gold Mining Operation in Central Nova Scotia, by Nova Scotia Department of Mines and Energy, 1984, 62 pages, 2 maps. **$5.00**

OFR ME 601 Metallic Mineral Occurrences Map and Data Compilation, Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), by M. Ponsford and N. A. Lyttle, 1984, 21 pages, 2 maps. **$3.00**

OFR ME 600 Metallic Mineral Occurrences Map and Data Compilation, Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11K, 11N), by M. Ponsford and N. A. Lyttle, 1984, 23 pages, 2 maps. **$3.00**

OFR ME 599 Metallic Mineral Occurrences Map and Data Compilation, Central Nova Scotia (Map Sheets 11D and 11E), by M. Ponsford and N. A. Lyttle, 1984, 21 pages, 2 maps. **$3.00**

OFR ME 329 The Glencoe Limestone and Dolomite Survey, by D. J. MacNeil, 1977, 252 pages, 12 maps. **$15.00**

OFR ME 50 Carboniferous Stratigraphy and Economic Geology, Halifax, Hants and Colchester Counties, Nova Scotia; Canadian Institute of Mining and Metallurgy, Geology Division, Field Guide, by Mining Society of Nova Scotia, Atlantic Geoscience Society and Nova Scotia Department of Mines, 1974, 48 pages. **$1.00**

OUTSIDE PUBLICATIONS

Various externally published reports and maps on geoscience topics authored by non-Minerals and Energy Branch staff.

!!!NEW!!!

OP ME 1998-2
A Special Issue Devoted to Lead-Zinc Mineralization and Basinal Brine Movement, Lower Windsor Group (Viséan), Nova Scotia, Canada; *in* Economic Geology and the Bulletin of the Society of Economic Geologists, v. 93, September-October 1998, no. 6, 260 pages. **$21.00**

OP ME 1998-1
Discovering Rocks, Minerals and Fossils in Atlantic Canada, A Geological Field Guide to Selected Sites in Newfoundland, Nova Scotia, Prince Edward Island, and New Brunswick, edited by P. Wallace, 1998, 186 pages; Atlantic Geoscience Society, Special Publication No. 14. **$25.00**

OP ME 1995-1 Proceedings: 30th Forum on the Geology of Industrial Minerals (1994), edited by S. A. A. Merlini, 1995; New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Miscellaneous Report 16, 261 pages. **$14.75**

!!!NEW!!!

OP ME 1991-1 A Guide to the Geology, Landscapes and Mineral Resources of Nova Scotia, by Craig K. Miller and G. C. Milligan, 1991; Atlantic Geoscience Society, Special Publication No. 6 (Preliminary Edition), 188 pages. **$5.00**

OP ME 1988-1 Atlantic Geoscience Society, Colloquium '88, Antigonish, N. S. (Abstracts of Papers). **$4.00**

OP ME 1987-2 The Mining Society of Nova Scotia 1887-1987, by D. Pigot, published by the Mining Society of Nova Scotia, June 1987, 125 pages. **$10.00**

OP ME 1987-1 Quaternary Glaciations, Geomorphology and Sea Level Changes: Bay of Fundy Region, by R. R. Stea, Field Trip, July 19-30, 1987, for NATO Advanced Study Institutes Programme, International Advanced Course on Late Quaternary Sea Level Correlations and Applications, Halifax, Nova Scotia; 79 pages. **$10.00**

OP ME 1986-5 Trip No. 14 Lithostratigraphic, Physical Diagenetic and Economic Aspects of the Pennsylvanian-Permian Transition Sequence of Prince Edward Island and Nova Scotia; H. W. van de Poll, J. R. DeGrace, R. J. Ryan, 1986; *in* Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985). **$7.00**

OP ME 1986-4 Trip No. 11 Turbidite-Hosted Gold Deposits, Meguma Domain, Eastern Nova Scotia; P. K. Smith, S. J. Haynes, B. E. Jones, 1986; *in* Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 67 pages. **$7.00**

OP ME 1986-3 Trip No. 10 Igneous and Metamorphic Geology of the Cape Breton Highlands; S. M. Barr, R. A. Jamieson, R. D. Raeside, 1986; *in* Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 48 pages. **$5.00**

OP ME 1986-2 Behind the Headlines: Moose River to Shangri-La, by Ralph Kelly Morton, 1986; *in* Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 197 pages. **$14.95**

OP ME 1986-1 Trip No. 1 Appalachian Geotraverse (Canadian Mainland); J. D. Keppie, K. Currie, J. B. Murphy, et al., 1986; *in* Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 181 pages. **$15.00**

OP ME 1981-1 Malagash Salt, compiled and edited by John R. MacQuarrie, c. 1975, 1981, 109 pages. **$5.00**

PAPERS

Detailed scientific papers on specific geoscience topics and/or specific areas.

Paper ME 1997-1 The Geology of a Portion of the South-Central Cape Breton Highlands (part of NTS map sheet 11K/07), Victoria and Inverness Counties, Nova Scotia, by L. J. Ham, 1997, 43 pages, plus 1 coloured map, Map ME 1997-1, scale 1:25 000 in back pocket. **$15.00**

Paper ME 1995-2 Geology of the South-Central Cape Breton Highlands (Parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia, by R. J. Horne, 61 pages, plus Map ME 1995-2 in back pocket. **$20.00**

Paper ME 1995-1 The Compositional Development of Tills Overlying the South Mountain Batholith, Nova Scotia, by P. W. Finck and R. R. Stea, 1995, 52 pages (includes Map ME 1992-2). **$15.00**

Paper ME 1994-1 A Diamond-Drilling Program near the Amherst Market, Investigating Bedrock Aggregate Potential in the Northwestern Cobequid Highlands, Nova Scotia, by G. Prime, 1994, 38 pages. **$4.00**

Paper ME 1993-2 Quaternary Stratigraphy and Placer Gold Potential of the Inner Scotian Shelf, by R. R. Stea, S. Pecore and G. B. J. Fader, 1993, 62 pages. **$7.00 (Microfiche $2.00)**

Paper ME 1993-1 An Evaluation of Debris Avalanches in the Central Cape Breton Highlands, Nova Scotia, by P. W. Finck, 1993, 65 pages. **$9.00 (Microfiche $2.00)**

Paper ME 1992-1 Surficial and Environmental Geology of the Western Cape Breton Highlands, Nova Scotia, by P. W. Finck, 1992, 22 pages plus map and 18 plates in back pocket. **$10.00 (Microfiche $2.00)**

Paper ME 1989-3 Re-evaluation of the Coal Resources of Western Cape Breton Island, by P. A. Hacquebard, K. S. Gillis and D. S. Bromley, 1989, 47 pages. **$12.00 (Microfiche $2.00)**

Paper ME 1989-2 Geology of the Mabou Highlands, by S. M. Barr and A. S. Macdonald, 1989, 65 pages and 1 geological map in pocket. **$15.00 (Microfiche $3.00)**

Paper ME 1989-1 Metallogenic Studies of Southeastern Cape Breton Island, by A. S. Macdonald, 1989, 99 pages, 3 figures in pocket. **$20.00 (Microfiche $3.00)**

Paper ME 1986-1 Cretaceous Deposits of Nova Scotia, by G. B. Dickie, 1987, 54 pages. **$15.00 (Microfiche $3.00)**

Paper ME 1985-2 The Formation of Veins in Greenschist Facies Rocks and the Early Deformation of the Meguma Group, Eastern Nova Scotia, by B. H. O'Brien, 1985, 35 pages. **$3.00 (Microfiche $1.00)**

Paper ME 1984-1 Petrology of Granitoid Rocks of the Boisdale Peninsula, Central Cape Breton Island, Nova Scotia, by S. M. Barr and J. R. D. Setter, 1986, 75 pages, includes Nova Scotia Department of Mines and Energy Map ME 1984-2 folded in back pocket. **$8.00 (Microfiche $2.00)**

Paper ME 1982-2 Metasomatic-Hydrothermal Mineral Deposits of the New Ross - Mahone Bay Area, Nova Scotia, by G. A. O'Reilly, E. J. Farley and M. H. Charest, 96 pages. **$5.00 (Microfiche $1.50)**

Paper ME 1982-1 Geology and Geochemistry of Selected Granitoid Plutons of Cape Breton Island, by S. M. Barr, G. A. O'Reilly and A. M. O'Beirne, 176 pages, 44 figures, 13 tables. **$8.00 (Microfiche $2.00)**

Paper ME 1981-4 Principles of Tectonic Mapping Based upon Plate Tectonic Theory, by J. D. Keppie, 11 pages. **$1.50 (Microfiche $1.00)**

Paper ME 1981-3 The Windsor Group of the Mahone Bay Area, Nova Scotia, by P. S. Giles, 51 pages, figure in back pocket. **$4.00 (Microfiche $1.50)**

Paper ME 1981-2 Major Transgressive - Regressive Cycles in Middle to Late Viséan Rocks of Nova Scotia, by P. S. Giles, 27 pages. **$2.00 (Microfiche $1.50)**

Paper ME 1981-1 The Fisset Brook Formation at Lowland Cove, Inverness County, Nova Scotia, by P. K. Smith and A. S. Macdonald, 18 pages. **$2.00 (Microfiche $1.00)**

Paper ME 1980-1 Geology of the Cape North Area, Northern Cape Breton Island, Nova Scotia, by A. S. Macdonald and P. K. Smith, 60 pages, 2 maps. **$5.00 (Microfiche $2.00)**

Paper ME 1979-7 Carbonate Banks of the Gays River Formation in Central Nova Scotia, by P. S. Giles, R. C. Boehner and R. J. Ryan, 57 pages, 1 map. **$4.00**

Paper ME 1979-6 Effects of Subsidence and Depositional Environment on the Formation of Lithotypes in a Hypautochthonous Coal of the Pictou Coalfield, by J. H. Calder, 23 pages. **$3.00**

Paper ME 1979-5 Pleistocene Stratigraphy of the Miller Creek Section, Hants County, Nova Scotia, by R. Stea and D. Hemsworth, 16 pages. **$3.00**

Paper ME 1979-4 Minor and Trace Element Variations in Wisconsinan Tills, Eastern Shore Region, Nova Scotia, by R. R. Stea and J. H. Fowler, 30 pages, 3 maps. **$10.00**

Paper ME 1979-3 Geology of the Meat Cove Zinc Deposit, Cape Breton Island, by A. K. Chatterjee, 27 pages. **$2.00**

Paper ME 1979-2 Opencast Coal Reserves at Springhill, by B. Ward, 40 pages, 4 maps. **$4.50**

Paper ME 1979-1 Petrology of the Late Precambrian Fourchu Group in the Louisbourg Area, Cape Breton Island, by J. D. Keppie, J. Dostal and J. B. Murphy, 18 pages. **$1.50**

Paper ME 1978-5 Petrology of the Early Silurian Dunn Point and McGillivray Brook Formations, Arisaig, Nova Scotia, by J. D. Keppie, J. Dostal and M. Zentilli, 20 pages. **$1.00**

Paper ME 1978-4 Some Middle Devonian to Lower Carboniferous Rocks of Cape George, Nova Scotia, by J. D. Keppie, P. S. Giles, and R. C. Boehner, 37 pages. **$2.00**

Paper ME 1978-3 Geology of the Giant Lake Area, Southeastern Cape Breton Island, Nova Scotia, by P. K. Smith, 30 pages, 1 map. **$2.00**

Paper ME 1978-2 Age of Igneous Rocks along the Lennox Passage - St. Peter's Lineament, Southern Cape Breton Island, by J. D. Keppie and P. K. Smith, 10 pages. **$1.00**

Paper ME 1978-1 Geology of the Ecum Secum Area, Halifax and Guysborough Counties, Nova Scotia, by D. McBride, 12 pages. **$1.00**

Paper ME 1977-7 Tungsten Mineralization in the Carbonate Rocks of the George River Group, Cape Breton Island, Nova Scotia, by A. K. Chatterjee, 26 pages. **$3.50**

Paper ME 1977-6 Sand and Gravel Resources of Pictou County, by J. H. Fowler and G. B. Dickie, 42 pages, 1 map. **$4.00**

Paper ME 1977-3 Plate Tectonic Interpretation of Paleozoic World Maps (with Emphasis on Circum-Atlantic Orogens and Southern Nova Scotia), by J. D. Keppie, 45 pages (Reprinted 1982). **$4.00 (Microfiche $1.50)**

Paper ME 1977-1 Tectonics of Southern Nova Scotia, by J. D. Keppie, 34 pages (Reprinted 1980). **$3.00**

Paper ME 1976-5 Guide to the Invertebrate Fauna of the Windsor Group in Atlantic Canada, by R. G. Moore and R. J. Ryan, 57 pages. **$2.25**

Paper ME 1976-4 Geology, Geochemistry and Mineral Occurrences of the Northeast Margaree River Drainage Basin in parts of Inverness and Victoria Counties, Cape Breton, Nova Scotia, by B. E. MacNabb, J. H. Fowler and T. G. N. Covert, 30 pages, 12 maps. **$15.00**

Paper ME 1976-3 Interpretation of P.P.I. Radar Imagery of Nova Scotia, by J. D. Keppie, 31 pages, 1 map. **$1.25**

Paper ME 1976-2 Geological Data Collection in the Nova Scotia Department of Mines, by J. D. Keppie and A. K. Chatterjee, 15 pages. **$0.50**

Paper ME 1976-1 Structural Model for the Saddle Reef and Associated Veins in the Meguma Group, Nova Scotia, by J. D. Keppie, 34 pages, 2 maps. **$3.00**

REPORTS

Various geoscience publications such as bibliographies, compilations, drill log summaries, indexes, report of activities.

Report ME 1998-2 Mining Matters for Nova Scotia '98: Opportunities for Economic Development, edited by D. R. MacDonald, 1998, 37 pages. **$5.00**

Report ME 1998-1 Minerals and Energy Branch Report of Activities 1997, edited by D. R. MacDonald and K. A. Mills, 1998, 212 pages. **$14.00**

Report ME 1997-1 Minerals and Energy Branch Report of Activities 1996, edited by D. R. MacDonald and K. A. Mills, 1997, 227 pages. **$12.00**

Report ME 1996-3 NTS Location Index to Minerals and Energy Branch Assessment Reports, Contribution Series, Open Files and Publications 1991-1995, by Janette M. Vavra, Norman A. Lyttle and J. Susan Saunders, 1996, 203 pages. **$11.00 (Microfiche $3.00)**

Report ME 1996-2 Author Index to Minerals and Energy Branch Assessment Reports, Contribution Series, Open Files and Publications 1991-1995, by Janette M. Vavra, Norman A. Lyttle and J. Susan Saunders, 1996, 362 pages. **$17.00 (Microfiche: $4.00)**

Report ME 1996-1 Minerals and Energy Branch, Report of Activities 1995, edited by D. R. MacDonald and K. A. Mills, 1996, 99 pages. **$9.00 (Microfiche $2.00)**

Report ME 1995-2 Program and Summaries, Nineteenth Annual Review of Activities, edited by D. R. MacDonald and K. A. Mills, 1995, 71 pages. **$5.00 (Microfiche $2.00)**

Report ME 1995-1 Minerals and Energy Branch, Report of Activities 1994, edited by D. R. MacDonald and K. A. Mills, 1995, 216 pages. **$14.00 (Microfiche $3.00)**

Report ME 1994-2 Program and Summaries, Eighteen Annual Review of Activities, edited by D. R. MacDonald, 1994, 75 pages. **$5.00 (Microfiche $2.00)**

Report ME 1994-1 Mines and Minerals Branch, Report of Activities 1993, edited by D. R. MacDonald, 1994, 245 pages. **$14.00 (Microfiche $3.00)**

Report ME 1993-2 Program and Summaries, Seventeenth Annual Review of Activities, edited by D. R. MacDonald, 1993, 65 pages. **$6.00 (Microfiche $2.00)**

Report ME 1993-1 Mines and Minerals Branch, Report of Activities 1992, edited by D. R. MacDonald and K. A. Mills, 1993, 203 pages. **$12.00 (Microfiche $3.00)**

Report ME 1992-2 NTS Location and Author Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches Assessment Reports, Contribution Series, Open Files and Publications for 1991, by Janette M. Vavra and Norman A. Lyttle, 1992, 178 pages. **$14.00 (Microfiche $3.00)**

Report ME 1992-1 Mines and Minerals Branch, Report of Activities 1991, ed. D. R. MacDonald, 1992, 122 pages. **$7.00 (Microfiche $2.00)**

Report ME 1991-4 Subject Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990, by Norman A. Lyttle and Janette M. Freeman, 1991, 5630 pages. (Microfiche only **$5.00)**

Report ME 1991-3 Author Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990, by Norman A. Lyttle and Janette M. Freeman, 1991, 508 pages. **$20.00 (Microfiche $5.00)**

Report ME 1991-2 NTS Location Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990, by Norman A. Lyttle and Janette M. Freeman, 1991, 452 pages. **$20.00 (Microfiche $5.00)**

Report ME 1991-1 Mines and Minerals Branch, Report of Activities 1990, ed. D. R. MacDonald, 1991, 140 pages. **$8.00 (Microfiche $3.00)**

Report ME 1990-1 Mines and Minerals Branch, Report of Activities 1989, Part B, ed. D. R. MacDonald, 1990, 112 pages. **$7.00 (Microfiche $2.00)**

Report ME 1989-1 Mines and Minerals Branch, Report of Activities 1988, Part B, eds. Y. Brown and D. R. MacDonald, 1988, 133 pages. **$9.00 (Microfiche $2.00)**

Report ME 1988-1 Mines and Minerals Branch, Report of Activities 1987, Part B, eds. D. R. MacDonald and Y. Brown, 292 pages. **$20.00 (Microfiche $4.00)**

Report ME 1987-4 Drilling Logs of Government Core Drills 1986, compiled by C. Kavanaugh, 1987, 64 pages. **$5.00 (Microfiche $2.00)**

Report ME 1987-2 Gold in Nova Scotia: A Bibliography of the Geology, and Exploration and Mining Histories from 1832 to 1986, by Janet Gillespie-Wood, 1986, 500 pages. **$25.00 (Microfiche $3.00)**

Report ME 1987-1 Mines and Minerals Branch, Report of Activities 1986, eds. J. L. Bates and D. R. MacDonald, 270 pages. **$15.00 (Microfiche $3.00)**

Report ME 1986-3 Drilling Logs of Government Core Drills 1985, compiled by I. MacDougall and D. E. Polley, 1986, 21 pages. **$3.50 (Microfiche $2.00)**

Report ME 1986-1 Mines and Minerals Branch, Report of Activities 1985, ed. J. L. Bates, 374 pages. **$12.00 (Microfiche $3.50)**

Report ME 1985-4 Drilling Logs of Government Core Drills 1984, compiled by I. MacDougall and D. E. Polley, 1984, 32 pages. **$3.50 (Microfiche $2.00)**

Report ME 1985-1 Mines and Minerals Branch, Report of Activities 1984, eds. K. A. Mills and J. L. Bates, 232 pages. **$10.00 (Microfiche $3.00)**

Report ME 1984-6 Bibliography of the Surficial Geology of Nova Scotia and the Offshore (with Radiocarbon Date List), by R. R. Stea and V. J. Brisco, 128 pages. **$6.00 (Microfiche $2.00)**

Report ME 1984-5 Drilling Logs of Government Core Drills 1983, compiled by I. MacDougall and D. E. Polley, 1983, 38 pages. **$3.50 (Microfiche $2.00)**

Report ME 1984-4 Keyword Index to Theses in Report ME 1981-6, by N. A. Lyttle and J. Gillespie-Wood. (Microfiche only **$5.00)**

Report ME 1984-1 Mines and Minerals Branch, Report of Activities 1983, eds. J. Szostak and K. A. Mills, 352 pages. **$10.00 (Microfiche $4.00)**

Report ME 1983-3 Drilling Logs of Government Core Drills 1982, compiled by I. MacDougall and D. E. Polley, 1983, 38 pages. **$3.50 (Microfiche $2.00)**

Report ME 1983-1 Mines and Minerals Branch, Report of Activities 1982, ed. K. A. Mills, 404 pages. **$10.00 (Microfiche $3.50)**

Report ME 1982-7 Uranium in Nova Scotia: A Background Summary for the Uranium Inquiry, Nova Scotia, 122 pages, 2 maps. **Out of Print (Microfiche only $2.00)**

Report ME 1982-6 Drilling Logs of Government Core Drills 1981, compiled by I. MacDougall and D. E. Polley, 1982, 60 pages. **$3.50 (Microfiche $1.50)**

Report ME 1982-5 Keyword Index to Geological Survey of Canada Documents on Nova Scotia to 1980. (Microfiche only **$2.00)**

Report ME 1982-4 Keyword Index to Open File Reports in Nova Scotia Department of Mines and Energy Report ME 1981-6, by N. A. Lyttle and J. Gillespie-Wood. (Microfiche only **$1.00)**

Report ME 1982-3 Keyword Index to Publications in Nova Scotia Department of Mines and Energy Report ME 1981-6, by N. A. Lyttle and J. Gillespie-Wood. (Microfiche only **$2.00)**

Report ME 1982-1 Mineral Resources Division, Report of Activities 1981, ed. K. A. Mills, 139 pages. **$7.00 (Microfiche $2.00)**

Report ME 1981-7 Index to Drillhole and Well Data 1862-1980, by N. A. Lyttle and J. Gillespie-Wood, 127 pages. **$10.00 (Microfiche $3.00)**

Report ME 1981-6 Index to Publications, Open File Reports and Theses, 1862-1980, by N. A. Lyttle and J. Gillespie-Wood, 222 pages. **$10.00 (Microfiche $3.00)**

Report ME 1981-5 Keyword Index to Assessment Reports 1864-1980, by N. A. Lyttle and J. Gillespie-Wood. (Microfiche only **$5.00)**

Report ME 1981-4 Index to Assessment Reports 1864-1980, by N. A. Lyttle and J. Gillespie-Wood, 109 pages. **$10.00 (Microfiche $3.00)**

Report ME 1981-3 Drilling Logs of Government Core Drills 1980, compiled by I. MacDougall and D. E. Polley, 52 pages. **$3.50 (Microfiche $1.00)**

Report ME 1981-2 Compilation of Igneous Chemical Analyses from Nova Scotia, up to 1978, compiled by J. D. Keppie, P. K. Smith and M. A. K. Grice, 114 pages. **$4.00 (Microfiche $2.00)**

Report ME 1981-1 Mineral Resources Division, Report of Activities 1980, ed. K. A. Mills, 199 pages. **$8.00 (Microfiche $2.00)**

Report ME 1980-3 Drilling Logs of Government Core Drills 1979, compiled by I. MacDougall and D. E. Polley, 68 pages. **$3.50 (Microfiche $1.50)**

Report ME 1980-2 Index to Drilling Logs of Government Core Drills 1972-78, by N. A. Lyttle and J. Gillespie-Wood, 47 pages. **$3.00**

Report ME 1980-1 Mineral Resources Division, Report of Activities 1979, 248 pages. **$7.00**

Report ME 1979-2 Drilling Logs of Government Core Drills 1978, by I. MacDougall and D. E. Polley, 54 pages. **$2.00**

Report ME 1979-1 Mineral Resources Division, Report of Activities 1978, 177 pages. **$6.00**

Report ME 1978-4 Compilation of Isotopic Age Data of Nova Scotia, by J. D. Keppie and P. K. Smith, 54 pages, 7 maps. **$7.00**

Report ME 1978-2 Drilling Logs of Government Core Drills 1977, by I. MacDougall and D. E. Polley, 72 pages. **$2.00**

Report ME 1978-1 Mineral Resources Division, Report of Activities 1977, 104 pages. **$4.00**

Report ME 1977-3 Drilling Logs of Government Core Drills 1976, by I. MacDougall and D. W. Grimm, 33 pages. **$1.00**

Report ME 1977-1 Mineral Resources Division, Report of Activities 1976, 207 pages. **$10.00**

Report ME 1976-3 Drilling Logs of Government Core Drills 1975, by I. MacDougall and D. W. Grimm, 47 pages. **$1.00**

Report ME 1976-2 Mineral Resources Division, Report of Activities 1975, 145 pages. **$3.00**

Report ME 1976-1 Drilling Logs of Government Core Drills, 1974, by I. MacDougall and D. W. Grimm, 73 pages. **$1.00**

Report ME 1975-1 Report of Activities of the Mineral Resources and Geological Services Division, 1974, by Nova Scotia Department of Mines, 75 pages. **$1.00**

SAMPLE CATALOGUES

Bound volumes containing rock or mineral commodity samples.

SC ME 1989-1 Nova Scotia Dimension Stone for Designers, Developers and Quarriers, 1989 (Comprehensive catalogue of 11 Nova Scotia building stones; includes actual sample tiles plus Information Series ME 19). **$100.00**

Appendix 3

Minerals and Energy Branch Digital Geoscience Data for Sale

DIGITAL COLLECTIONS	FORMAT	SIZE/MEDIA	PRICE
DC 001. Complete set of all Nova Scotia Department of Natural Resources digital geoscience data (except digital products DP 001a, DP 001b and the plot files from DP 008), version 1, 1997	E00, DXF/DBF, TIFF	478 Mb, 1 CD-ROM	$215.00

MAPS	FORMAT	SIZE/MEDIA	PRICE
D94-08. Geological Map of Bridgetown, Nova Scotia [21A/14], [1:50 000], version 1, 1997, compiled by M. A. MacDonald and L. J. Ham, 1994 (line work only, no point data)	E00	360 Kb, 1 disk	$ 5.00
	DXF/DBF	587 Kb, 1 disk	$ 5.00
D94-07. Geological Map of Digby, Nova Scotia [21A/12], 1:50 000, version 1, 1997, compiled by L. J. Ham, 1994 (line work only, no point data)	E00	373 Kb, 1 disk	$ 5.00
	DXF/DBF	493 Kb, 1 disk	$ 5.00
D94-04. Geological Map of Weymouth, Nova Scotia [21A/05], version 1, 1997, compiled by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000 (line work only, no point data)	E00	106 Kb, 1 disk	$ 5.00
	DXF/DBF	200 Kb, 1 disk	$ 5.00
D94-03. Geological Map of Wentworth Lake, Nova Scotia [21A/04 and parts of 20P/13], version 1, 1997, compiled by L. J. Ham and M. A. MacDonald, 1994, scale 1:50 000 (line work only, no point data)	E00	156 Kb, 1 disk	$ 5.00
	DXF/DBF	243 Kb, 1 disk	$ 5.00
D94-02. Geological Map of Lake Rossignol, Nova Scotia [21A/03 West], version 1, 1997, compiled by M. C. Corey and R. J. Horne, 1994, scale 1:50 000 (line work only, no point data)	E00	76 Kb, 1 disk	$ 5.00
	DXF/DBF	88 Kb, 1 disk	$ 5.00
D94-01. Geological Map of the South Mountain Batholith, Western Nova Scotia [parts of 11D and 21A], version 1, 1997, compiled by M. A. MacDonald, 1994, scale 1:250 000 (line work only, no point data)	E00	1.5 Mb, 1 disk	$ 5.00
	DXF/DBF	1.6 Mb, 1 disk	$ 5.00
D92-03. Surficial Geology Map of the Province of Nova Scotia, version 1, 1997, compiled by R. R. Stea, H. Conley and Y. Brown, 1992, scale 1:500 000.	E00	20 Mb, 3 disks	$15.00
	DXF/DBF	22 Mb, 2 disks	$10.00

DIGITAL COLLECTIONS	FORMAT	SIZE/MEDIA	PRICE
D90-14. Cumberland Basin Geology Map Tatamagouche and Malagash, Cumberland, Colchester and Pictou Counties, Nova Scotia [11E/11 and 11E/14 south], version 1, 1997, compiled by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000 (line work only, no point data)	E00	400 Kb, 1 disk	$ 5.00
	DXF/DBF	458 Kb, 1 disk	$ 5.00
D90-13. Cumberland Basin Geology Map Oxford and Pugwash, Cumberland County, Nova Scotia [11E/12 and 11E/13], version 1, 1997, compiled by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000 (line work only, no point data)	E00	600 Kb, 1 disk	$ 5.00
	DXF/DBF	763 Kb, 1 disk	$ 5.00
D90-12. Cumberland Basin Geology Map Amherst, Springhill and Parrsboro, Cumberland County, Nova Scotia [21H/08, 21H/09 and 21H/10], version 1, 1997, compiled by R. J. Ryan, R. C. Boehner, A. J. Deal and J. H. Calder, 1990, scale 1:50 000 (line work only, no point data)	E00	500 Kb, 1 disk	$ 5.00
	DXF/DBF	600 Kb, 1 disk	$ 5.00
D90-11. Cumberland Basin Geology Map, Apple River and Cape Chignecto, Cumberland County, Nova Scotia [21H/07 and 21H/10], version 1, 1997, compiled by R. J. Ryan and R. C. Boehner, 1990, 1:50 000 (line work only, no point data)	E00	300 Kb, 1 disk	$ 5.00
	DXF/DBF	408 Kb, 1 disk	$ 5.00
D86-02. Geological Map of the Windsor Area, Nova Scotia [21A/16 north and 21H/01 south], version 1, 1997, compiled by R. G. Moore and S. A. Ferguson, 1986, 1:25 000 (line work only, no point data)	E00	864 Kb, 1 disk	$ 5.00
	DXF/DBF	832 Kb, 1 disk	$ 5.00
D86-01. Geological Map of the Sydney Basin-Cape Breton, Nova Scotia [11K/01, 11K/08 and 11J/04], version 1, 1997, compiled by R. C. Boehner and P. S. Giles, 1986, scale 1:50 000 (line work only, no point data)	E00	1.2 Mb, 1 disk	$ 5.00
	DXF/DBF	1.6 Mb, 1 disk	$ 5.00
D85-02. Geology of Loch Lomond Basin and Glengarry Half Graben, Nova Scotia [11F/15 east and 11F/16 west], version 1, 1997, compiled by R. C. Boehner and G. Prime, 1985, scale 1:50 000 (line work only, no point data)	E00	500 Kb, 1 disk	$ 5.00
	DXF/DBF	610 Kb, 1 disk	$ 5.00
D85-01. Industrial Mineral Commodities Map of the Province of Nova Scotia, version 1, 1997, compiled by J. H. Fowler, 1985, scale 1:500 000.	E00	200 Kb, 1 disk	$ 5.00
	DXF/DBF	200 Kb, 1 disk	$ 5.00
D84-02. Geological Map of the Boisdale Peninsula, Central Cape Breton Island, Cape Breton County, Nova Scotia [parts of 11F/15, 11F/16, 11K/01 and 11K/02], version 1, 1997, compiled by S. M. Barr and J. R. D. Setter, 1984, scale 1:100 000 (line work only, no point data)	E00	258 Kb, 1 disk	$ 5.00
	DXF/DBF	371 Kb, 1 disk	$ 5.00

DIGITAL COLLECTIONS	FORMAT	SIZE/MEDIA	PRICE
D83-05. Metallogenic Map of Nova Scotia, version 1, 1997, compiled by A. K. Chatterjee, 1983, scale 1:500 000 (includes the inset map **Metallogenic Associations and Domains of Silver,** scale 1:1 000 000).	E00	4 Mb, 1 disk	$ 5.00
	DXF/DBF	6 Mb, 1 disk	$ 5.00
D83-01. Geological Map of the Hantsport Area, Nova Scotia [21H/01], version 1, 1997, compiled by S. A. Ferguson, 1983, scale 1:25 000 (line work only, no point data)	E00	459 Kb, 1 disk	$ 5.00
	DXF/DBF	609 Kb, 1 disk	$ 5.00
D82-09. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 4 of 4 [11E/06, 11E/07 west and 11E/10 west], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00	600 Kb, 1 disk	$ 5.00
	DXF/DBF	649 Kb, 1 disk	$ 5.00
D82-08. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 3 of 4 [11E/05 and 11E/12], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00	500 Kb, 1 disk	$ 5.00
	DXF/DBF	690 Kb, 1 disk	$ 5.00
D82-07. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 2 of 4 [21H/08 and 21H/09], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00	600 Kb, 1 disk	$ 5.00
	DXF/DBF	650 Kb, 1 disk	$ 5.00
D82-06. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 1 of 4 [21H/07], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00	400 Kb, 1 disk	$ 5.00
	DXF/DBF	391 Kb, 1 disk	$ 5.00
D82-05. Geology Map of the Northern Antigonish Highlands, Nova Scotia [11E/09, 11E/16, 11F/12 and 11F/13], version 1, 1997, compiled by J. B. Murphy, J. D. Keppie and A. H. Hynes, 1991, scale 1:50 000 (line work only, no point data)	E00	38 Kb, 1 disk	$ 5.00
	DXF/DBF	38 Kb, 1 disk	$ 5.00
D82-04. Geological Map of the Shubenacadie and Musquodoboit Basins, Central Nova Scotia [11D/13, 11D/14, 11E/02 west, 11E/04 east and 11E/03], version 1, 1997, compiled by P. S. Giles and R. C. Boehner, 1982, scale 1:50 000 (line work only, no point data)	E00	1 Mb, 1 disk	$ 5.00
	DXF/DBF	1.4 Mb, 1 disk	$ 5.00

DIGITAL COLLECTIONS	FORMAT	SIZE/MEDIA	PRICE
D82-03. Geological Map of the Eureka Area, Central Nova Scotia [11E/07D and 11E/10A], version 1, 1997, compiled by P. S. Giles, 1982, scale 1:50 000 (line work only, no point data)	E00	200 Kb, 1 disk	$ 5.00
	DXF/DBF	195 Kb, 1 disk	$ 5.00
D82-02. Geological Map of the Antigonish Basin, Nova Scotia [parts of 11E/09, 11F/12 and 11F/13], version 1, 1997, compiled by R. C. Boehner and P. S. Giles, 1982, scale 1:50 000 (line work only, no point data)	E00	691 Kb, 1 disk	$ 5.00
	DXF/DBF	920 Kb, 1 disk	$ 5.00
D79-03. Bouguer Gravity Anomaly Map of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:500 000.	E00	1 Mb, 1 disk	$ 5.00
	DXF/DBF	2 Mb, 1 disk	$ 5.00
D79-01S. Structural Map of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:1 000 000 (insert from Map 79-1)	E00	1 Mb, 1 disk	$ 5.00
	DXF/DBF	1.5 Mb, 1 disk	$ 5.00
D79-01M. Metamorphic Map of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:1 000 000 (insert from Map 79-1)	E00	700 Kb, 1 disk	$ 5.00
	DXF/DBF	1 Mb, 1 disk	$ 5.00
D79-01. Geological Map of the Province of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:500 000 (does not include the 1:1 000 000 structural and metamorphic inset maps).	E00	5 Mb, 1 disk	$ 5.00
	DXF/DBF	6 Mb, 1 disk	$ 5.00
D1752a. Geological map of northern Cape Breton Island, Nova Scotia [11K/02, 11K/03, 11K/06 to 11K/16, 11N/01, 11N/02] [1:100 000], version 1, 1997, compiled by S. M. Barr, R. A. Jamieson, R. P. Raeside, 1992, Geological Survey of Canada, Map 1752a.	E00	2 Mb, 1 disk	$ 5.00
	DXF/DBF	2 Mb, 1 disk	$ 5.00
DP 001a. Mineral occurrence query program, version 2, 1997. (This is a viewing and searching program with instructional manual (40 pages) for use with DP 001b Mineral Occurrence Database)	EXE	3 Mb, 2 disks	$10.00
DP 001b. Mineral occurrence database, version 3, 1998. This database can be used with DP 001a, the Mineral Occurrence Query Program.	DBF	7 Mb, 2 disks	$10.00
DP 002. Mineral occurrence database, version 3, 1998.	E00	4 Mb, 1 disk	$ 5.00
	DXF/DBF	7 Mb, 1 disks	$5.00
DP 003. Drillholes database, version 1, 1996.	E00	55 Mb, 3 disks	$15.00
	DXF/DBF	16 Mb, 2 disks	$10.00
DP 004. Regional geochemical datasets (biogeochemical, lake and stream sediment, lake and stream water, soil, rock and till geochemical surveys), version 1, 1996.	E00	24 Mb, 3 disks	$15.00
	DXF/DBF	19 Mb, 2 disks	$10.00

DIGITAL COLLECTIONS	FORMAT	SIZE/MEDIA	PRICE
DP 009. Claim reference map grid, Nova Scotia, version 1, 1997.	E00	1.4 Kb, 1 disk	$ 5.00
	DXF/DBF	1.2 Kb, 1 disk	$ 5.00
DP 010. Abandoned mine openings database, version 1, 1997.	E00	3.8 Mb, 1 disk	$ 5.00
	DXF/DBF	3 Mb, 1 disk	$ 5.00
DP 005. Airborne gamma ray spectrometric survey images, elemental and elemental ratio images covering 11D, 11E, 11F, 11G, 11J, 11K, 11N, 20O, 20P, 21A, 21B and 21H), version 1, 1997 (250 m x 250 m resolution).	TIFF	14 Mb, 4 disks	$20.00
DP 006. Airborne magnetometer survey images, total field and vertical gradient images covering 11D, 11E, 11F, 11G, 11J, 11K, 11N, 20O, 20P, 21A, 21B and 21H, version 1, 1997 (250 m x 250 m resolution).	TIFF	8 Mb, 2 disks	$10.00
DP 007. Airborne synthetic aperture radar (SAR) images covering 11D, 11E/01, 11E/02, 11E/03 and 11E/04, version 1, 1997, (6 images, 25 m x 25 m resolution).	TIFF	59 Mb, CD-ROM	$20.00
DP 008. Meguma Terrane enhanced second vertical derivative aeromagnetic digital data, version 1, 1997. Includes: (a) images in TIFF format of the aeromagnetic data from OFM's 97-7 to 97-28 and 97-30 to 97-33, without topographic base information or legends; (b) contractor's report on the processing methodology; (c) plot files in HP-GL/2 format of OFM's 97-7 to 97-28 and 97-30 to 97-33.	TIFF	573 Mb, CD-ROM	$20.00